ELECTRONIC MAIL: TOMORROW'S STANDARD FOR BUSINESS COMMUNICATION?

HIGH TECHNOLOGY

JANUARY 1987 THE MAGAZINE FOR TECHNOLOGY MANAGEMENT PRICE $3.00

REMOTELY PILOTED VEHICLES: COMPUTERS WITH WINGS

GETTING DOWN TO BUSINESS ON AIDS

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NEC NEWSCOPE

NEW 32-BIT CMOS MICROPROCESSORS.

The two new members of NEC's CMOS microprocessor V-Series bring unprecedented density and performance in the 32-bit realm. The V60 and V70 supermicros are the first to integrate a Memory Management Unit and basic floating-point processing functions on a single chip.

The V60 has a 16-bit external data bus for an easy, affordable path into 32-bit products while the V70 is a full 32-bit engine designed to power leading-edge systems.

The super-fast V60 and V70 offer a clock speed of 16MHz, and execute 3.5 MIPS and 6 MIPS respectively. A six-stage pipelined CPU enables concurrent execution of up to 4 instructions. With 32 on-board 32-bit general-purpose registers, there is no need to access slow off-chip memory.

The V60/V70 feature an on-chip memory management unit with 4 gigabytes of demand-paged virtual memory space, and 4 levels of memory protection for multi-tasking and multi-user environments.

The V60/V70 instruction set is ideal for high-level languages and OS support (UNIX™ V and proprietary realtime OS). There are 21 addressing modes, 273 instructions, and an emulation mode for 16-bit V20/V30 software.

UNIX: trademark of AT&T Bell Laboratories.

C&C
Computers and Communications

NUMBER 136

COMING SOON: 1.3/1.55μ DFB LASER DIODES.

Dispersion has always been a major obstacle in long-distance, high-speed light-wave communications. With conventional laser diodes emitting multiple spectrums, pulses deteriorate by dispersion after long travel through the fiber. This in turn limits repeater span to 20—30km and capacity to 400—560Mbps for the prevalent 1.3μ fiber optic systems.

NEC has overcome this obstacle with newly-developed distributed feedback (DFB) laser diodes for 1.3μ and 1.55μ fiber optic transmission systems. They feature a stable single longitudinal mode operation, high efficiency and high output power. The new DFB laser diodes are expected to expand repeater span to 80—100km for 1.3μ system or 100—200km for 1.55μ system.

NEC's new DFB laser diodes inherit the renowned double channel planar-buried heterostructure (DC-PBH) and have a diffraction grating in the optical guide region to produce a single wavelength. Output powers are rated 8mw for the 1.3μ NDL5600 and 5mw for the 1.55μ NDL5650. They come in the TO-5 package with an integral monitor photo diode or chip-on-carrier configurations.

As matching light-receiving devices, NEC has planar type InGaAs avalanche photo diodes. They have a selective guard ring construction to achieve high sensitivity and excellent reliability.

NEW INTELLIGENT BUILDING COMPLEX AT VANCOUVER.

The intelligent building is an idea whose time has come. As the perfect nestling for office workers in the Information Age, it centers on an advanced information management system which provides simultaneous voice, data and image services to tenants at less cost while it controls the entire building environment efficiently.

The World Trade Centre/ Pan-Pacific Vancouver Hotel recently opened is just such an installation. NEC's NEAX 2400 Information Management System (IMS) allows tenants to utilize enhanced telephone/facsimile services including least-cost routing, message center and voice mail services, and computer terminal connection via a multifunction digital telephone set. The NEAX 2400 IMS also offers sophisticated services to hotel guests.

NEC's Intelligent Building Systems, based on our unique C&C (integrated computer and communications) technology, are the most advanced and comprehensive available today. As the core of this system, the modular NEAX 2400 IMS can expand to 255 tenant partitions. It supports more than a hundred advanced features including a protocol converter to allow communication with most popular host computers. NEC also supplies comprehensive component equipment including multifunction digital telephones, information display pagers, high-speed facsimiles, business and personal computers, teleconferencing and CATV equipment and local distribution microwave links.

NEC's comprehensive systems breathe new life into the smart building concept, bringing costly services like teleconferencing within the reach of every business.

NEW HIGH-CAPACITY 64QAM DMR SERIES.

NEC's newest 800 Series high-capacity digital microwave radio (DMR) systems transmit two or three DS3 signals per RF carrier, utilizing 64-state quadrature amplitude modulation (64QAM) for effective use of radio spectrum.

Three systems meeting FCC standards are available: a 4GHz 90M-bit system providing 1,344 voice channels, and 6GHz and 11GHz 135M-bit systems for 2,016 voice channels.

The new systems incorporate the latest LSIs, hybrid and microwave ICs throughout to achieve compact design, lower power consumption and improved system reliability. Housed in a standard 19-inch rack, they require minimal cabling work for installation.

The advanced 800 Series is fully compatible with Bell's facility maintenance and administration system.

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JANUARY 1987

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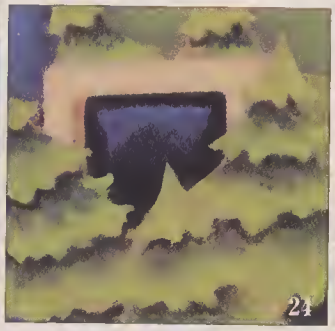

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OPINION

REDEDICATION OF A MAGAZINE WITH A MISSION

HIGH TECHNOLOGY has moved into its sixth year of publication with a renewed sense of commitment. Its purpose has always been to provide decisionmakers with early warning of the new technologies that bring about change in products, the workplace (whether factory, office, or laboratory), and the marketplace. But the need for such information has become ever more intense as global competition has intensified—not only in traditional industries but also in the high technology sectors once dominated by the United States.

Just as a strong organization must have good financial and marketing management, it must now also have informed and action-oriented technology managers, who must address such questions as: Do products incorporate optimum technologies? Do communications systems take advantage of the great strides being made in networks and information handling? Are employees using the most effective tools to increase productivity? Are manufacturing and distribution systems flexible enough?

If key decisionmakers do not have sound ways to keep on top of these and similar issues, the organization, no matter how large or successful it may have been in the past, is doomed to go the way of the dinosaur.

This magazine is dedicated to meeting that information need. One way is in making our articles timely, informative, accurate, and accessible. Thus, while the editors have a wide range of technical expertise—they have written books, for example, on artificial intelligence, a leading microcomputer, and monoclonal antibodies—their goal is to communicate clearly about frontier technologies to business people whether or not the reader has an extensive technical background.

Another way is in making the magazine easier to read and more attractive. Its new look, making its debut with this issue, was crafted by Martin Pederson, a distinguished designer whose many credits include the recent redesign of *Business Week*, and Anne McAuliffe, HIGH TECHNOLOGY's art director.

A magazine, like any other product, must keep improving in order to serve its market well. We know, from constant contact with our readers, that we've so far been on track. But our research also shows that this audience of technology business people have information needs that are rapidly changing. We aim to keep pace with, or even to get a bit ahead of, that change to help you do a more effective job than ever. Thus we always welcome your comments, whether compliments or criticisms.

Thanks for your support.

Robert Haavind

Robert Haavind

HIGH TECHNOLOGY

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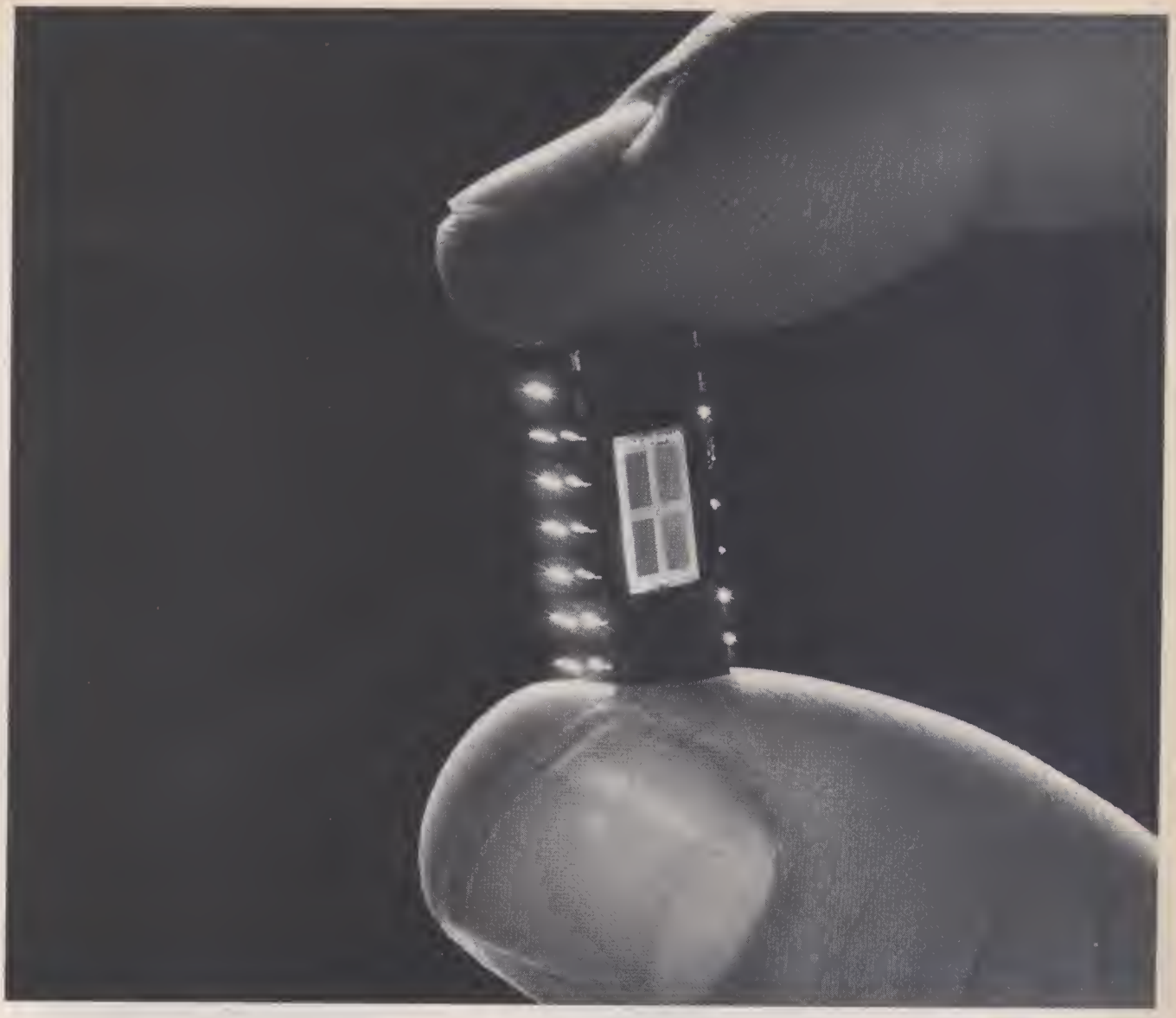

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Retraining U.S. workers to regain world leadership

Your Opinion "Technology can't solve factory woes without a change in attitudes" (Oct. 1986, p. 4) fails to point out two critical trends.

The first is the preference by our engineering graduates—strongly supported by misguided company management and university faculties—for desk jobs and other executive assignments. Even though the real action is in the laboratory, shop, and design office, few seem to be interested in working there.

The second issue is the failure by factory management to make up for the loss of the "old-world skilled hands" who seem to have faded away since the first half of this century. Little is being done to institute effective apprenticeship and training programs to raise the skill levels of our blue-collar work force.

Better attitudes in labor relations may help motivate workers, but our industry will not be competitive unless we also provide proper training.

Gary Nothmann
Principal Engineer
Xerox Special Information Systems
Pasadena, Cal.

What's in stock for automated retail

Your article "Automated retail" (Sept. 1986, p. 24) was well researched, but it had a few misleading statements.

Some top-of-the-line boards used for in-store marketing systems may have a remarkable 16.8-million-color palette, but only 16 simultaneous colors are available to the screen at one time.

You state that IBM has been testing a NAPLPS videodisc genlocking product. For three years such black boxes have also been available from small manufacturers. Technology is apparently not considered credible until IBM gets in the game.

Bob Tuss of Vancouver, B.C., stated that producing 12-inch videodiscs costs roughly $10,000 and requires a four- to eight-week turnaround. This is probably true in Canada. My Michigan-based company ships discs to 3M in Minnesota on the average of once a month and gets them back in three days for less than $3000. If we can wait a week or two, the mastering costs are reduced to less than $2000. Depending on quantity, each disc costs only $7.50 to $18. "Draw" discs and discs for one- or three-of-a-kind applications can be acquired in one day for as low as $300.

Lastly, eight-inch discs *don't* lower pressing costs dramatically (as Tuss stated) and should not be related to lower-quality reproduction. The eight- or 12-inch disc, and the one-day, three-day, or eight-week turnaround, should all provide a quality visually indistinguishable from the one-inch master tape from which the discs are generated.

Stan Williams, President
Full Circle Communications
Dearborn, Mich.

ILLUSTRATION BY BOB DAHM

Yankee ingenuity lives

Contrary to Robert Noyce's viewpoint in "Reviving Yankee ingenuity" (Nov. 1986, p. 10), I believe that good old Yankee ingenuity is alive and well in our companies. One sees so little evidence of it mainly because it has been buried in layers of bureaucracy by budgeteers and bean-counters. Manufacturing engineers, like any other group of engineers, enjoy challenges. Nothing is more rewarding than seeing one's ideas take shape and begin to function. But in today's corporate environment, that happens too infrequently. People charged with making decisions and recommendations often do not speak the language of the engineer and have little concept of the things he or she is trying to accomplish.

Imagine the success rate, then, when an enthusiastic engineer tries to convince the manager to spend some money to improve something the manager doesn't even understand. After being thwarted a few times, the engineers' zeal begins to dim and they spend more time studying the company's retirement plan and drawing house plans.

Engineers are doing as much today as they are allowed to do—but not nearly as much as they can do—to improve America's productivity. If results are what you want, give them free rein and stand back!

Don Wilson
Phoenix, Ariz.

Mosquitoes took the bite out of radar

I read "Radar countermeasures" (Aug. 1986, p. 56) with interest; however, one of the hardest aircraft to detect—the British de Havilland Mosquito—was not mentioned. Except for the engines and the two propellers, which gave a unique radar image, it was one of the hardest aircraft to detect because it was built of plywood (which absorbed radar).

Peter J. Lewis
Mississauga, Ontario

Rabbit Systems, referred to in "Rising stars in consumer electronics" (Dec. 1986, p. 22), is located in Santa Monica, Cal., not Santa Clara.

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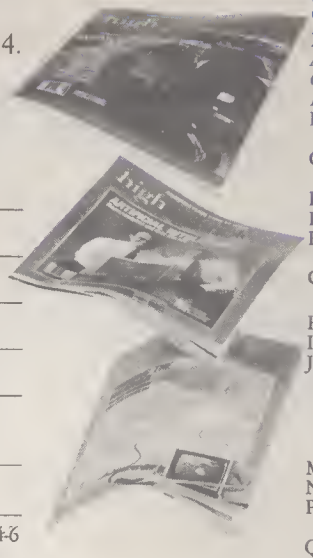

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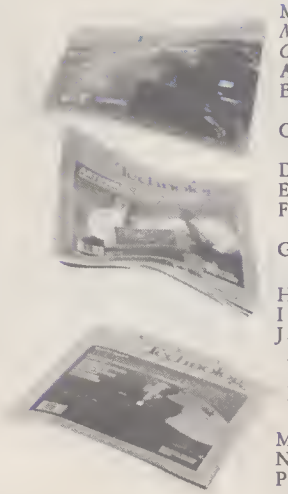

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ILLUSTRATION BY BOB DAHM

HOW GENERAL MOTORS IMPROVES ITS TOP END PERFORMANCE.

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INNOVATIONS

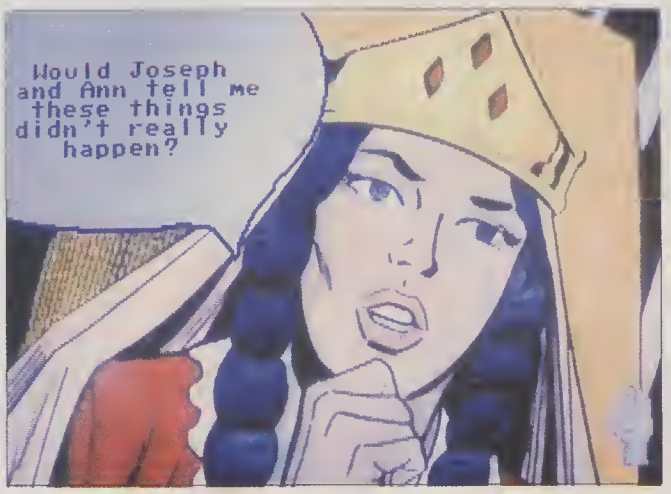
Computers target adult illiteracy

The battle against illiteracy, once fought mainly with chalk and print, is now being waged electronically. A computerized learning center called PALS (Principle of the Alphabet Literacy System), recently introduced by IBM, is designed to teach reading and writing to teenagers and adults whose skills are at or below the fifth-grade level.

A PALS center typically consists of four videodisc systems linked to eight PCjr computers, four PC/XTs, and four electronic typewriters. Students use the PCjrs and the typewriters along with lesson manuals to practice writing exercises, learning to touch-type as they go. The PC/XTs enliven reading lessons with videodisc-based comic books that students control by touching the screen. At the same time, computer-stored voice speaks the dialogue that the student sees on screen.

PALS isn't cheap; a complete center costs $72,000, or $60,000 with an educational discount. But IBM says the system can accommodate 500 students a year—and it seems to work. In high-school trials of the system, students' reading skills improved by an average of three grade levels after 20 weeks. IBM plans to make PALS generally available in the second quarter of this year, and expects it to be used in such settings as junior high and high schools, correctional facilities, and civic organizations.

"PALS may well be able to help a big chunk of the population," says Elizabeth Laugharn, deputy director of the Department of Education's Adult Literacy Initiative. She says roughly 20 million Americans fall into IBM's target category.



Users of IBM's PALS literacy system see dialogue on screen as it's being spoken by a computer.

Japan pursues optical chips

Japan has embarked on a 10-year project to develop integrated circuits that incorporate lasers, light sensors, and transistors all on the same chip. The goal of the 10-billion-yen ($65 million) program is to make an optoelectronic IC (OEIC) containing 20–30 lasers, each capable of switching on and off 10 billion times a second, according to Tatsutoku Honda, a director of the government-backed Optoelectronic Industry and Technology Development Association.

Such chips could serve in proposed optical computers capable of working 1000 times faster than today's electronic ones. Closer at hand—probably within five years, says Honda—is a single-chip repeater for long-distance fiber optic links. A detector on one side of the OEIC could convert light signals from an input fiber into electrical form; after amplification by a transistor on the chip, the resulting current would modulate a laser connected to the chip's output fiber, allowing the optical signals to continue on their journey with renewed intensity. OEICs could also enable graphic data to be transmitted all at once instead of being converted into a bit stream; a laser array on one chip would light up to display an image that would then be read by a sensor array on the receiving chip.

The project, spearheaded by the newly formed Optoelectronic Technology Research Corp., faces major challenges. Making a high-density OEIC, for example, will mean shrinking diode lasers from their present length of 300 microns to about 1 micron. And while electronic circuits run in silicon, most optical devices are based on gallium arsenide or indium phosphide, which require different fabrication techniques. The Japanese are focusing on technologies (such as metal-organic chemical vapor deposition) that can marry these dissimilar materials.

Satellite links for mariners

A new satellite-communications system promises to bring reliable telex, electronic mail, and navigational and positioning services to every vessel that plies the seas, including fishing boats and pleasure craft. Developed by the London-based International Maritime Satellite Organization (Inmarsat), the system, called Standard C, uses Inmarsat's three geostationary satellites but is a smaller, lower-cost version of the Standard A data terminals now installed on about 5000 large commercial ships.

Although satellite communications suffers from neither the bad-weather interference that plagues marine high-frequency radio nor the line-of-sight distance limitations of marine VHF, the conventional Standard A terminals require a large parabolic antenna and complex receiving and transmitting equipment, costing around $30,000. Standard C terminals, however, can send and receive via a small omnidirectional antenna. The key is a transmission scheme that repeats each bit of digital data, decreasing the likelihood that a receiver will misread the message and thus permitting the use of weaker signals. According to Inmarsat, a complete marine earth station should cost less than $5000.

Inmarsat has already built a 13-pound prototype earth station about the size of a marine VHF radio, and production models

are expected to be small enough to mount on a vessel's mast. Several European companies are reportedly working on Standard C equipment, including special chips for receiving and decoding the satellite transmissions. The service is expected to begin in late 1987 or early 1988.

Company R&D growth to slow in '87

United States industry's research and development spending will increase only 5% in 1987, a marked decline from the 13% average growth of the last 10 years, according to a National Science Foundation survey released in November. Industry officials attribute the decline to poor sales expectations in durable-goods industries, concerns about short-term profitability, and the need to restructure R&D efforts after corporate mergers.

The electrical equipment industry plans the largest increase—10%. Manufacturers of machinery, including computers, plan a 7% increase, chemicals and aircraft 6%, instruments and primary metals 5%, and motor vehicles 4%. Oil companies forecast an 11% decrease.

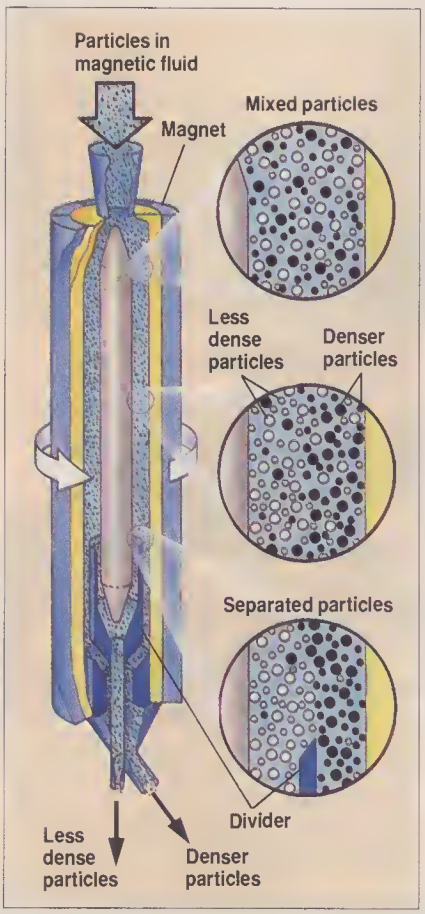
Hiring is also expected to slacken. Three-quarters of the surveyed companies reported that employment of scientists and engineers for R&D was growing even slower than total funding. They pointed to higher computer and instrument costs, rising salaries, and increased contracting out of research.

Sludge in, metals out

A technique that carefully balances the effects of magnetism and centrifugal force could greatly speed the recovery of valuable metals from vast tracts of ocean floor. Patented by Intermagnetics General (Guilderland, N.Y.), the materials separation process could also extract residual minerals from underground ore and from the "tailings" left behind at conventional mining sites.

In the Magstream process, a mixture of mined particles is blended with a magnetic liquid (typically, a suspension of iron oxide in water) and poured into the top of a spinning vertical cylinder. As the centrifugal force throws the particles outward, a magnet surrounding the cylinder tugs at the fluid, buoying the particles inward. The lighter the material, the more it responds to this magnetically generated buoyancy, and the more easily it overcomes the centrifugal force. At the bottom of the cylinder, a physical divider separates the heavy grains near the outer wall from the lighter material near the hub. Adjusting the magnetic field and the rotation speed alters the balance of forces, enabling even materials of similar density to be separated cleanly.

In the Magstream process, minerals (denser particles) are separated from dirt or sand by centrifugal force and magnetism.



Intermagnetics recently sold its first system to the U.S. Geological Survey, which will use it to analyze samples from the ocean floor. A typical separation involves the extraction of heavy minerals such as rutile (which contains titanium) and zircon (containing zirconium) from quartz-based rocks and sand. Unlike procedures currently used in laboratories, the separator does not rely on heavy liquids such as bromoform, which are toxic and difficult to handle.

One lens does the work of several

Cameras, binoculars, and the like may soon be able to use fewer lenses, thanks to a new type of optics being refined at the University of Rochester. Ordinarily, an imaging instrument needs a complex series of lenses—differing in shape and refractive index (light-bending ability)—to produce a large, sharp picture. In addition to being bulky, these assemblies are susceptible to misalignment. But if the optical glass is processed so that its refractive index varies in a controlled way across its thickness, fewer components can be made to do the same job.

Working under a $500,000 Army contract, Duncan Moore of Rochester's Institute of Optics recently fabricated a 50-mm-diameter element that can replace two of the three conventional lenses in the military's standard M-19 binoculars. To make such "gradient-index" lenses, the glass is immersed in a molten salt bath; sodium ions migrate out of the glass, and silver ions from the bath take their place, changing the refractive index. The desired index profile is created by controlling the composition and temperature of the bath, the duration of the immersion, and the extent of subsequent heat treatment. The Army contract permitted the first demonstration that this procedure could be made economical and reliable, says Moore.

Although the technology is being launched by the military, Moore has formed a company, Gradient Lens (Rochester), to market the lenses to manufacturers of cameras and other optical equipment.

INSIGHTS

MANUFACTURING WITH A HUMAN FACE

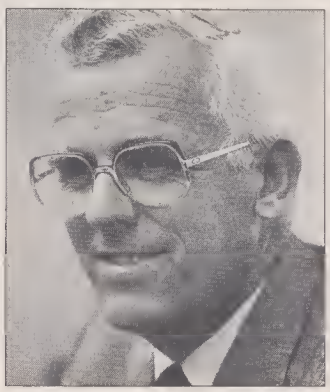
MARTIN KUILMAN, VICE-PRESIDENT
N.V. PHILIPS'S GLOEILAMPENFABRIEKEN

A large part of the competitive battle of the future will be waged on the factory floor. But what will that "factory of the future" actually look like? Will it be totally unmanned—a huge mechanical edifice without people, lighting, or heating? Will it be a data-processing plant in which machines are simply peripherals on a vast computer network and the only personnel are programmers and information analysts? Or will it be a utopian commune, where the distinction between work and leisure has virtually disappeared—where people work harmoniously with each other and with user-friendly technology?

These three sketches are obviously simplistic, but there is an abundance of literature in which such caricatures are taken seriously. The fact is that a single model of the factory of the future, especially one that is fanciful and one-dimensional, will not do. The complex world of manufacturing, ranging from custom-built to mass-produced goods—encompassing nails, VLSIs, bicycles, and ships—will never fit into a single factory system.

New manufacturing technologies will certainly play a central role. Sophisticated computer systems will be needed not only to tie mechanical systems together but to orchestrate new and increasingly complex operations. Yet because manufacturers the world over have more or less the same access to technology, the race for global markets will be decided not by the machinery but by the quality of the people at all levels and the relationships between them. Although there will be fewer workers engaged in the primary processes, they will face tougher challenges: shorter throughput times, more limited stocks (as the just-in-time inventory concept takes hold), and greater pressure to produce high-quality goods. Only motivated and highly qualified personnel will be able to respond fast enough to constantly changing market conditions and unforeseen events.

Production personnel, for example, should increasingly become discussion partners of people in plant engineering and product development. They must participate not only in innovation—the creation of new products or processes—but in the continuous improvement of what already exists. If workers are to be involved in this way, however, they must feel genuine motivation. And that is where the role of managers comes in. Intimidation and coercion—some of the traditional means of securing short-term worker responses—will just not do for the factory of the future. Management approaches are clearly in need of fundamental reappraisal.



A company must cultivate excellent human relations in order to use its machines effectively.

Thus technological and social innovation will have to go hand in hand. That is the main lesson to be learned from the Japanese. They built some of the world's most advanced factories not through technological superiority but through their effective organizations—by the commitment and motivation of all their people. In order for the West to ensure that its factories of the future will be world-class producers, it must do likewise. Specifics will vary from place to place—Japanese, European, and American companies, after all, are different, just as their cultures are different—but each in its own way must cultivate excellent human relations in order to use its machines effectively.

That challenge is especially great considering where industry is going—driven in large measure by product offerings from the Far East, which have made customers more quality-conscious and accustomed to frequent model changes—and where it has been. The traditional efficiency-oriented manufacturing approach, characterized by a rigorous differentiation of tasks, is being replaced by a more flexible approach that stresses versatility in both the technology and the jobs on the factory floor. Efficiency is no longer the overriding imperative in manufacturing; traditional mass production and batch manufacturing are incapable of providing sufficient quality and variety fast enough and at low enough cost.

Thus the flexibility of the factory of the future and the bureaucracy of the factory of the past do not mix. Leadership at the flexible organization must be strong, but relationships with staff must be participatory rather than authoritarian. And interdepartmental barriers must be minimal in order to assure a rapid flow of information throughout the company. The linkages between decisions and actions must be simple and direct.

The shift from a conventional efficiency-oriented organization to a flexible factory will clearly not be easy—especially for management—and will undoubtedly require trial and error. But worker motivation throughout the transformation must be maintained. And the greatest threat to employee morale will come from a one-sided technical approach on management's part that treats the unmanned factory, or the information-processing factory, as if it were a fait accompli.

It's people that make the difference in manufacturing, now and in the future. And if we utilize them with intelligence and compassion, we can succeed in keeping Western industries at least on a par with those of our competitors. □

N.V. Philips's Gloeilampenfabrieken is an electronics manufacturer based in Eindhoven, the Netherlands.

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CONCURRENT COMPUTER:

MOVING INTO ON-LINE TRANSACTIONS

Last winter, Concurrent Computer, formerly the Data Systems Group of Perkin-Elmer, was the darling of Wall Street. When the Tinton Falls, N.J., company went public last January, three months after its formation, the initial stock offering was underwritten by some of the nation's most prominent investment banking firms, despite the continuing computer slump. And with good reason. Profits of $13.1 million on revenues of $262.8 million for the year ended the previous July made Concurrent (still 83% owned by Perkin-Elmer) a solid, second-tier superminicomputer vendor. Its product line, some of which incorporates parallel processors (hence the name Concurrent), had carved itself several strong niches, mainly in real-time processing.

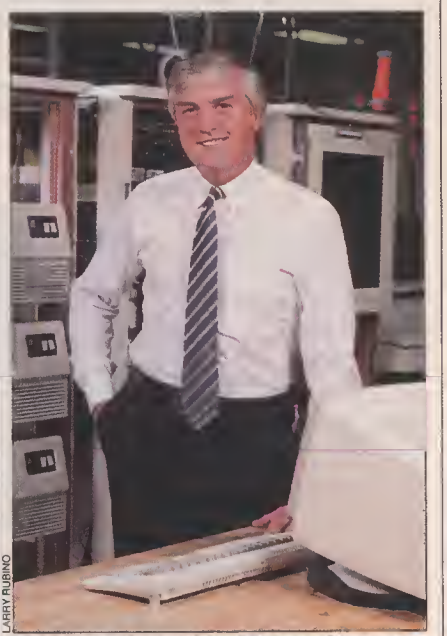
So when Concurrent's revenues tumbled in early 1986, resulting in the group's first losing quarter in four years, it came as quite a "negative surprise," says Jeffrey Canin, an analyst for Hambrecht & Quist (San Francisco). For the year ended in July, profits were down to $6.1 million on revenues of $244.8 million.

Concurrent's 3200 family of minicomputers over the years had developed a solid reputation in the engineering market. They were especially strong in monitoring and simulation applications for the aerospace, mining, and petroleum industries, markets dominated by Digital Equipment. (The company also carries a line of computers based exclusively on the popular Unix operating system, but with only 250 installed, most observers consider it an insignificant "me-too" product line.) Concurrent's 11,000 installations, however, account for just 0.8% of the market for computers in the $15,000–$250,000 range, estimates William Rosser, VP of mid-range computer services for The Gartner Group in Stamford, Conn.

Recently, Concurrent has been trying to grow by establishing itself in the lucrative on-line transaction processing market, consisting of applications such as banking and airline reservations that involve frequent interactions with a central database. It's a field in which parallel processing is particularly beneficial, maintains company president James Sims, because peak-load tasks can be shared. And the redundant components found in some Concurrent 3200 models provide additional backup for vital transactions.

Already, the company has begun selling systems to the financial services industry and to a slightly unusual niche: the organizations that run state lotteries. Unavoidably, though, Concurrent will find itself butting heads with the field's market leader, IBM, as well as with smaller, more specialized companies. Chief among these are fault-tolerant computer makers such as Tandem and Stratus, which, like Concurrent, provide redundancy and backup features. However, a possible advantage for Concurrent over some of these firms, notes Hambrecht & Quist's Canin, is the 3200's ability to run Unix (in addition to a proprietary operating system), a plus in selling to government offices, some of which are switching exclusively to Unix.

Despite its lackluster year, Concurrent is still looked on favorably by analysts and market researchers, many of whom predict a recovery in 1987. A step in that direction took place in May, when the company announced a joint venture with Japan's Nippon Steel to sell Concurrent hardware in Japan coupled with Nippon's factory monitoring software. And in August, Concurrent began volume shipments of a long-awaited powerful new member of its 3200 line. Sims also reports that the company is investigating artificial intelligence applications as a possible new market. ***—Mary Jo Foley***



LARRY RUBINO

Concurrent's president, James Sims, sees commercial applications for parallel processors.

RIBI IMMUNOCHEM RESEARCH:

HELPING THE BODY FIGHT CANCER

Most biotech companies use recombinant DNA techniques to produce specific antiviral and antitumor substances—such as interferon and interleukin-2—derived from the body's immune system. Ribi ImmunoChem Research, a five-year-old firm in the Rocky Mountain town of Hamilton, Mont., is taking a different approach. Ribi uses biological agents to stimulate the immune system itself so that it can more effectively produce whatever substances are needed to fight cancer and other diseases.

Ribi's technique grew out of observations made early in the century that some people suffering from advanced cancer recovered completely after having bacterial infections. William B. Coley, a New York surgeon of the time, reasoned that the body's defenses against the infection were also squelching the cancer, and intentionally infected some patients to test his theory. Unfortunately, the bacteria caused serious—and sometimes fatal—illnesses. Coley's procedure was largely forgotten as other cancer treatments, such as surgery, radiation, and chemotherapy, became common.

A breakthrough came in 1978 when microbiologist Edgar Ribi of the National Institute for Allergy and Infectious Disease in Hamilton found a way to detoxify endotoxin, the component of bacteria that triggers the immune system. Ribi discovered that treatment with certain acids decomposed endotoxin into two constituents—monophosphoral lipid A (MPL) and treha-

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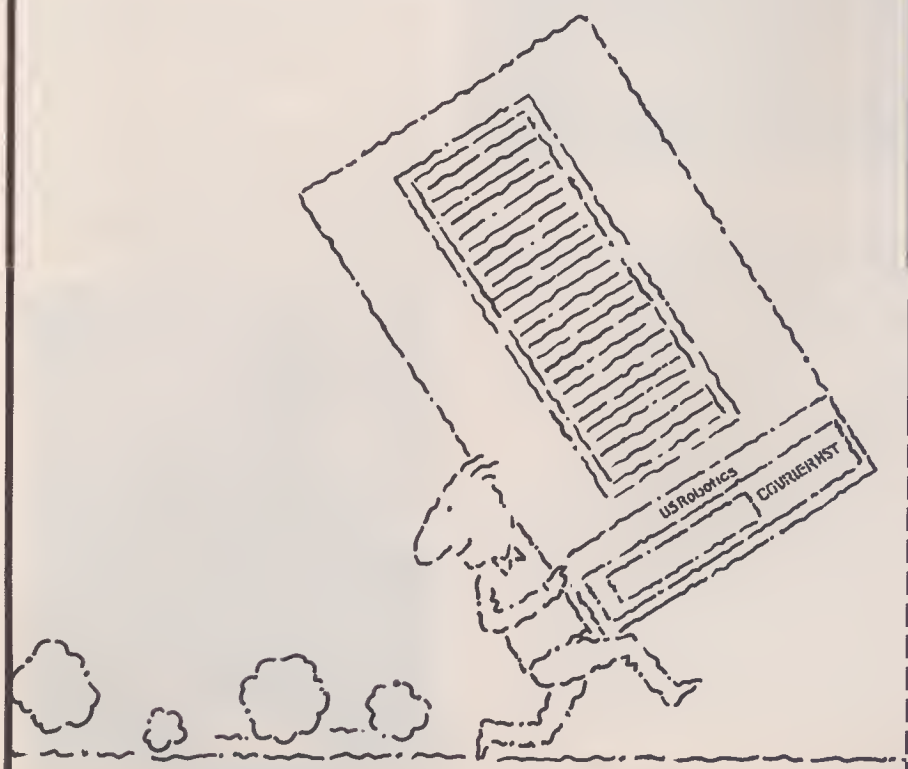

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lose dimycolate (TDM)—and that injection of these substances raised the body's natural defense against cancer and infectious disease without causing illness. Varying the proportions of the MPL and the TDM yields drugs optimized against different conditions.

The first bacterial brew to hit the market was Ribigen, introduced in 1983 to treat certain kinds of cancer in cattle and since used on horses and dogs as well (tests on humans were unsuccessful). Ribigen is injected directly into solid tumors; within weeks, not only is the injected tumor gone, but so are many secondary tumors, reflecting generalized enhancement of immunity.

While Ribigen remains strictly a veterinary product, Ribi has recently developed two other drugs intended for eventual use in humans; both await FDA approval. One of them, Ovamid, appears effective against cervical and ovarian cancers in mice. But the company's biggest potential success is a versatile concoction called Detox. In early trials, Detox has successfully treated the remnants of early-stage melanoma left behind after surgery. It "has a significant chance to be a major new oncology drug," according to analyst Scott R. King of Montgomery Securities (San Francisco).

A more widespread use for Detox may be for the removal of genital warts, which now afflict 1–4 million people. In addition to this $100 million potential market, there are plans to test the drug against common warts. The company hopes that because Detox's safety has already been demonstrated in the cancer trials, a wart-removal preparation will sprint through the FDA obstacle course, reaching the market in two or three years.

In yet another application, Detox also decreases the severity of radiation poisoning if given before exposure. Large doses of radiation tear holes in the intestinal wall, allowing the bacteria that normally dwell there to infect the body, with sometimes lethal results. Detox apparently inhibits such leakage. This effect could make the drug particularly useful for cancer patients undergoing radiation therapy and for workers in nuclear plants.

Ribi is also targeting infectious disease. The Ribi Adjuvant System (RAS), now being tested in animals, may strengthen vaccines against hepatitis, AIDS, herpes, rabies, meningitis, and pneumonia. RAS will be particularly helpful for the new synthetic vaccines, which are safer than whole-organism versions but also weaker. RAS amplifies these vaccines 100 times more than the drugs now available as adjuvants (enhancers). As a bonus, RAS diminishes skin eruptions at injection sites.

Owing to the heavy R&D costs that burden any biotech start-up, Ribi has yet to make a profit, admits president and chief operating officer Nils Ribi, Edgar Ribi's son. (The elder Ribi died in a plane crash in August.) Still, the financial picture is brightening: during the first nine months of 1986, the company lost $181,000 on revenues of $1.2 million, versus a $418,000 loss on $615,000 in revenues for the same period of 1985. Analysts at Kidder, Peabody & Co., which underwrote a 1985 public stock offering that brought in $9.5 million, predict that revenues will top $32 million by 1990 as the company's products become available for use in humans.

Ribi's remote location bolsters the company's financial situation. Costs are low; the 9000-square-foot building that the company built for under $500,000 would have run $2–3 million in Silicon Valley. But the out-of-the-way home may also be prolonging the firm's obscurity; several New York–based analysts who follow the biotech industry claim never to have heard of the company.

Reaching out from its geographic isolation, Ribi is collaborating with about 20 other biotechnology companies. Typically, the collaborators team up to test a new Ribi adjuvant with synthetic vaccines produced by the other company. So far, however, Ribi remains the only company attempting to commercialize drugs that enhance the body's overall immune system. □ ***—Ricki Lewis***

VIDAR SYSTEMS:

SCANNERS THAT BRIDGE MANUAL AND COMPUTERIZED DESIGN

Using computers instead of manual drafting to aid in engineering and architectural design has many well-advertised charms, including lower costs, greater speed, and higher productivity. But despite their appeal, computer-aided design (CAD) techniques have been slow to catch on, due partly to resistance to change and partly to the lack of a convenient bridge between the world of paper and the electronic manipulation of information. As a result, "most product design is still done on paper and stored in file drawers," says William Altmann, VP for marketing of Vidar Systems (Herndon, Va.). His two-year-old firm is out to change that with a new type of document scanner introduced early in 1986.

Until recently, the market consisted mostly of low-end machines called page scanners, which cost $6000–$10,000 and can handle only standard, letter-size pages of typescript. Vidar's 4200 series of large optical scanners, costing $35,000–$70,000, handle complex documents up to 42 inches wide, thereby enabling the computerized storage and manipulation of design, engineering, and architectural drawings.

As one of the first companies to market such products, Vidar has an opportunity to blossom in a new area where total sales through 1995 could exceed $6.5 billion, according to Linda Helgerson, market analyst at Diversified Data Resources (Falls Church, Va.).

Vidar found the early going slow. Despite the scanner's obvious virtues, the company had to educate customers about

Vidar president Robert Hanfling expected competition from an IBM or a Xerox, but they've not yet jumped in.

JON FEINGERSH

its merits before they would buy, just as manufacturers had to educate supermarkets about the optical scanners now used widely at checkout counters. "I didn't expect that we would have to shape the market as well as sell our products," says Robert Hanfling, Vidar's president. "And I thought we'd be fighting for the number two or three position behind an IBM or Xerox, whose large sales force and advertising would develop the market quickly." But the giants have not yet jumped in.

Vidar has made one important strategic change since its founding in 1984. Originally, the company planned to sell complete systems—scanners, printers, workstations, and software—to end users. But the firm lacked the resources to supply and service entire systems. Instead, Vidar now sells only scanners and markets only to original equipment manufacturers and system integrators. The switch seems to be working. Vidar's scanner was part of an industrial document management system introduced by 3M last fall; Digital Equipment (Maynard, Mass.) is marketing Vidar's scanner with its products, and Datagraphic Systems plans to fold Vidar's machine into a turnkey system likely to be used first in automobile design. Vidar also envisions an opportunity to work with whoever wins Navy and NASA prime contracts for systems that can manage technical drawings.

Vidar is shipping 15–25 large scanners a month, which it claims is at least half the market and more than the output of its two chief rivals—Skantek (Warren, N.J.) and Optigraphics (San Diego)—combined.

The commercial prospects for these machines depend largely on the availability of software that can simplify the scanning process. "Capturing the image and putting it into a CAD station is currently a complex and time-consuming task," says Jack Gold, strategic marketing manager for engineering and support services at Digital Equipment. "It takes three or four steps, and a lot of information is lost in the transfer, especially when an image is converted from raster (two-dimensional) format to vector (three-dimensional) format for use in a CAD system." But if the lag between scanner development and software creation can be overcome, Vidar's Hanfling reckons there is almost no major industrial application—from aerospace to automotive design to power plants—"where I cannot make a good economic case for scanners." ***—Richard J. Myers***

THE ELECTRONIC MAILBOX: AS CLOSE AS YOUR PC

Corporate and public message networks continue to grow as services become easier to use

When Stan Prochaska, a public affairs supervisor at the U.S. Department of Agriculture in Washington, D.C., sits down at his desk in the morning, he ignores his in-box. "First thing I do," he says, "is check my electronic mailbox—often there are as many as 20 messages waiting for me—and then I answer my mail from my terminal."

When Prochaska logs on to an electronic mail service provided by Dialcom (Silver Spring, Md.) from his desktop personal computer, he scans the contents of his mailbox, deciding which items to read, which to hold for later, and which to discard, all with a few keystrokes. A request for information on pesticides from an agricultural extension office in Orlando, Fla., might be answered by a brief typed reply, together with electronic copies of press releases and news items located by a quick search of the USDA's database. A message that includes information on crop yields from the USDA's office in Lincoln, Neb., can be copied onto a floppy disk for inclusion in a press release, which will later be disseminated by the electronic mail system.

Prochaska logs on several times a day. "People who want to reach me know they can do it faster and more reliably this way than by telephone," he says. "When I travel, I take a portable computer and dial in to my electronic mailbox from the motel or even an airport lounge."

Despite a growing number of confirmed users of electronic mail—computer-based messaging systems that let users send documents and data to other users, for retrieval at will, over corporate or even worldwide networks—the spread of such services has been slower than early proponents predicted. The first public systems were hard to use and thus had few subscribers. But recently developed software for terminals and personal computers is making the writing, sending, and receiving of electronic correspondence easier, faster, and cheaper than regular postal mail. And as private electronic mail is becoming the backbone of networked office automation systems, public electronic mail systems are scrambling to link up with major corporate networks and even with each other. As a result, electronic mail use appears to be approaching the critical mass that could make it the medium of choice for business communications in the near future.

The concept of electronic mail has been around for more than a decade. Users of the Defense Department's ARPAnet have had a nationwide mail network for several years based on computers at universities and laboratories. Users of large time-shared computer systems have long been able to send messages to other users, as have subscribers to remote computing services such as CompuServe (Columbus, Ohio) and The Source (McLean, Va.).

But the real growth has come only in recent years, as major corporations have adopted sophisticated office automation systems with electronic mail facilities. The computers that many businesses bought in the early 1980s largely for word processing have now evolved into versatile and extensive systems connecting

by Jeffrey Bairstow

WILLIAM HUBER

BBN's Terry Crowley checks an experimental "multimedia" electronic mail system that combines text, graphics, photographic images, spreadsheets, and voice.

hundreds of users to computer networks that can span a single office or an entire company with worldwide offices and plants. Typically these systems integrate several applications, such as word processing, calendar scheduling, database management, financial spreadsheets, computer programming, and data processing. In addition, says Edward Thomas, manager of office automation systems for Data General (Westboro, Mass.), "we find that customers [for office automation systems] are demanding networking and electronic mail."

Thomas also points out that more business managers and executives are prepared to use a computer terminal or a PC themselves instead of delegating the work to a secretary. For such executives, reliable and rapid communication with other managers is of prime importance. Thus electronic mail is becoming well established in large and medium-size companies. Altogether, there are about 4 million in-house electronic mailboxes in the U.S., estimates Michael Cavanagh, executive director of the Electronic Mail Association (EMA), an industry trade group based in Washington, D.C.

Typical of the electronic mail facilities offered by office automation packages is the one included with Data General's Comprehensive Electronic Office (CEO). A user, after logging on to the computer system from a desktop terminal or a personal computer, is presented with a menu of options. Selecting electronic mail allows the user to compose messages that can be sent to other users on the same computer or on a network. Alternatively, documents previously prepared with the CEO word processor or spreadsheet program can be included in an electronic letter. Each mail user has an electronic inbox where messages accumulate for reading at a convenient time. A user can then read, answer, forward, file, print, or delete messages with a few keystrokes.

Some other office automation systems

with sophisticated electronic mail facilities are All-In-One from Digital Equipment Corp., PROFS (Professional Office System) and DISOSS (Distributed Office Support System) from IBM, and Wang Office from Wang Laboratories.

While in-house electronic mail has been spreading rapidly, the growth of public electronic mail services has been slower, according to EMA's Cavanagh. There are only about a million subscribers to the dozen or so public electronic mail services in the U.S., provided by MCI, Western Union, General Electric, Telenet (US Sprint), and others. Although messaging was provided earlier by some computer timesharing services, large public electronic mail services date from about 1982, when Western Union (Upper Saddle River, N.J.) first introduced its EasyLink service, followed by MCI (Washington, D.C.) with MCI Mail. Revenues from electronic mail services are estimated at $270 million in 1986, according to International Resource Development (Norwalk, Conn.), and are expected to grow to $1.2 billion in 1990.

Some 200 million pieces of public electronic mail were dispatched last year, says Eric Arnum, editor of *Electronic Mail and Micro Systems* (*EMMS*), an industry newsletter. By contrast, 140 billion pieces of mail are carried annually by the U.S. Postal Service—about 560 pieces per person, versus only about 200 per public electronic mail subscriber. A recent study by Venture Development Corp. (Framingham, Mass.) summed up the problem with one basic truth: "The primary reason people are not using electronic mail is because they can't communicate with the people they need to communicate with."

Until recently, purely electronic messages could be sent only to another subscriber on the same system. To ease this limitation, virtually all the public electronic mail systems are linked to telex networks, so a message can be sent directly to a telex subscriber (and vice versa, in most cases). If the addressee subscribes to neither electronic mail nor telex, messages can be printed out at one of the service provider's centers, usually by high-speed laser printer on a facsimile of the user's own letterhead, and sent by regular mail or courier to a conventional mail address. But in many cases, this method of delivery is no faster than regular mail or a package service, and may be even more expensive.

In recent months, however, there has been a flurry of announcements, both by private electronic mail vendors and by public service providers, of new interconnections among electronic mail systems. For example, Wang Laboratories (Lowell, Mass.) now offers a gateway, or specialized communications package, that allows electronic mail to be sent between users of its VS Office and users of the popular PROFS office automation package, which runs on large IBM computers. Messages can be sent without added complications or special routines, says Jacqueline Appel, office automation sales manager for Wang.

Digital Equipment Corp. (Merrimack, N.H.) offers a similar gateway, VAX Mailgate, that permits DEC VAX computers running the All-In-One office automation system to communicate with MCI Mail subscribers and services. MCI also provides independent software developers with technical support to encourage them to write links to MCI Mail for private electronic mail systems. One such firm, SoftSwitch (King of Prussia, Pa.), recently announced a link to MCI Mail for IBM mainframe computers running PROFS.

Western Union has gone a step farther, offering two types of links between its EasyLink electronic mail network and IBM's PROFS and DISOSS office automation systems. The software for these links resides on EasyLink computers, so IBM users need not install non-IBM software on their systems. One PROFS interface is a high-speed connection, for high-volume users, that performs as another (multiuser) node on an IBM PROFS network. The other interface, for lower-volume users, appears to the IBM system as a single remote terminal. In neither case are any modifications to the IBM systems required—a major selling point for data processing executives who wish to keep their systems "pure" IBM. AT&T Mail (Basking Ridge, N.J.) offers similar benefits to UNIX users. Any computer system running the UNIX operating system can connect to AT&T Mail via the electronic mail software routines normally provided as part of the operating system.

The most significant extension of electronic mail to date came with a recent internetwork link that allows the 75,000 MCI Mail subscribers to communicate with the 275,000 users of CompuServe's EasyPlex remote access services. MCI has also announced an overseas link to France's Missive service. And Telenet (Reston, Va.), the provider of the U.S.-based Telemail service, began a link to Telecom Canada's Envoy service to give Canadian electronic mail subscribers access to Telemail's worldwide network.

Despite all this progress, most of these links require proprietary software and are specially developed for each application. "The interconnection of electronic mail systems is not yet as straightforward as the interconnection of telephone systems," says Douglas Brackbill, senior marketing manager for MCI. "Most links do not conform to international standards."

But work on such standards is moving forward. The Consultative Committee on International Telephony and Telegraphy (CCITT), an international standards body, has had a study group working on electronic mail standards since 1981. The CCITT Message Handling Standards group has produced a set of interoperability standards known as X.400, based on the protocols of the Open Systems Interconnect (OSI) model (HIGH TECHNOLOGY, Sept. 1986, p. 30). The X.400 standards have been adopted by CCITT and endorsed by the U.S. National Bureau of Standards, as well as by the Corporation for Open Systems (COS), the U.S. computer industry group formed to encourage communications compatibility for computer systems. COS is expected to establish a test laboratory to verify that X.400-based products will operate as intended.

Pressure to adopt X.400 appears stronger in Europe, where electronic mail systems are often part of the national telephone companies (PTTs) and thus more closely regulated than in the United States. One international electronic mail service provider, Dialcom, a former ITT subsidiary now owned by British Telecom, has demonstrated an X.400-compatible electronic mail system, and other providers are expected to follow suit shortly. Dialcom has a strong incentive to adopt X.400, since much of its business is derived from licenses for its electronic mail services to PTTs in Europe and Asia. Ensuring compatibility between these PTT systems and private electronic mail systems is a priority for Dialcom, says John Morris, the company's president.

But in the U.S., where IBM holds sway over computer communications and network architecture, X.400 is faring less well. Computer links must be compatible with IBM's System Network Architecture

THE PUBLIC ELECTRONIC MAILBOX POPULATION

Company	Subscribers
CompuServe EasyPlex	275,000
WU EasyLink	130,000
Dialcom (British Telecom)	100,000
OnTyme (McDonnell Douglas)	85,000
MCI Mail	75,000
Telemail (US Sprint)	70,000
GE Quick-Comm	65,000
CompuServe InfoPlex	30,000
RCA Mail	25,000
AT&T Mail	20,000
Others	100,000
TOTAL	975,000

SOURCE: THE YANKEE GROUP

MICHAEL SCHNEPS

Macintosh-like PC software makes electronic mail easier for executives, claims GE's Norman McBurney.

JOHN TROHA/BLACK STAR

"Interconnection is the issue," says Walter Ulrich of Coopers and Lybrand, "and standards are forcing it."

(SNA), which is incompatible with the OSI model; and electronic mail must be compatible with IBM's Document Content and Interchange Architecture (DCA/DIA), which is incompatible with X.400.

Some computer industry experts believe that these factors could slow the growth of electronic mail in the U.S. "We do not expect to see a resolution [between IBM's architectures and X.400] very soon," says Joseph Forgione, group manager of communications for Data General. "In fact, the two standards will probably exist well into the 1990s." Thus Data General and other non-IBM manufacturers expect that they will have to provide both IBM and X.400 links for their computer systems. Independent software developers are already active in this area. One of the first X.400-based messaging software products for in-house use has been introduced by Sydney Development Corp. (Vancouver, B.C.), based on work done at the University of British Columbia. Sydney's software also has gateways to IBM's PROFS and the MS-DOS operating system, an important requirement for large companies with IBM mainframes and personal computers.

IBM will not comment on its plans for future products, but the company is a member of COS—an affiliation that may hint at some eventual accommodation with OSI and X.400. For example, "IBM could make parts of its proprietary SNA protocols public property under the OSI banner," says Arnum of *EMMS*. The opening of SNA would certainly speed the interconnection of computer systems and networks for non-IBM manufacturers.

CCITT is also developing standards for directories. With an electronic mail system on a single computer, a central directory of users is easy to set up and maintain. In a complex electronic mail network with many computers in several locations, accessing and updating a global directory becomes a massive task; so a more realistic solution is to have smaller local, or "distributed," directories. There are still no generally accepted standards either for directories or for methods of addressing to find subscribers. But a CCITT study group has been examining the problem for almost three years. "I expect to see standards [for distributed directories] within a year," says Richard Miller, president of Telematics International (Palo Alto, Cal.) and a former delegate to CCITT.

The adoption of standards for directories could raise some difficult privacy questions, says Walter Ulrich, a partner at Coopers and Lybrand (Houston). "A company might want to make its directory available to customers but not, say, to a firm of headhunters," notes Ulrich. "When there is widespread interconnection of electronic mail systems, there is potential for misuse of directory information." One solution might be for a company to publish its electronic mail address but not its internal directory. Thus an employee might give his mailbox address only to specific outsiders, who would keep their own personal directories on a PC, much as individuals now keep a personal telephone book.

Standardization may help to expand the universe of subscribers, but electronic mail users also need improved screen displays, or user interfaces. Early systems often followed a telex-like pattern and required the use of codes and abbreviations that had to be followed exactly. "Electronic mail is, for the most part, still difficult to use," says Jack Nilles, director of

ELECTRONIC MAIL HEADS TOWARD CRITICAL MASS

Electronic mail systems currently make up a $375 million market in North America, some 18% of a broader $2.1 billion electronic messaging market. This larger market encompasses a variety of technologies—including telex, facsimile, and voice mail equipment—used to transmit noninteractive messages over telecommunications links. By 1990, revenues from electronic mail systems are expected to top $1 billion, accounting for 29% of an overall $3.5 billion electronic messaging market, according to International Resource Development, a market research firm based in Norwalk, Conn.

Public services and private in-house systems represent the two major segments of the electronic mail market. About a million individuals subscribe to public services, according to Steve Glagow, manager of strategic business services at Walter Ulrich Consulting (Houston). Western Union (Saddle River, N.J.) controls 20–25% of this market; other participants include MCI (Washington, D.C.), GTE Telenet (Reston, Va.), British Telecom's Dialcom (Silver Spring, Md.), General Electric Information Services Co. (Rockville, Md.), and McDonnell Douglas (St. Louis). Message services are also offered as part of a broad array of communications options by CompuServe (Columbus, Ohio) and The Source (McLean, Va.).

Private systems, serving some 4 million people, are used by corporations, often in conjunction with integrated office automation systems. This market is dominated by the major computer manufacturers, including IBM (Armonk, N.Y.)—with about a 40% share—Digital Equipment Corp. (Merrimack, N.H.), Data General (Westboro, Mass.), Wang (Lowell, Mass.), and Hewlett-Packard (Palo Alto, Cal.).

"Computer-based message systems are spreading like wildfire," says Stephen Kirchoff, marketing manager for electronic mail at DEC. "Our company, for example, has grown from 2000 users to 50,000 on our own internal network in six years."

Two major factors lie behind such expansion. One is the increasing interconnectivity between public systems, private networks, and other forms of communications, such as telex and facsimile machines. "Connectivity is the key to the market's future," says J. Robert Harcharik, founder of MCI Mail and now an independent consultant in Washington, D.C, "because it brings to the industry a critical mass of individuals."

"Electronic mail systems can now transmit spreadsheet files, graphics, databases, and computer programs, as well as textual messages. Such added capabilities will help attract more customers."
Douglas Brackbill
Senior Marketing Manager, MCI

While connectivity is now developing on a case-by-base basis, such as the link between MCI Mail and CompuServe, the X.400 international electronic mail interconnection standard, set in 1984 by the Consultative Committee on International Telephony and Telegraphy, could open the door to worldwide networks. Public services based on X.400 are slated to begin operation this year in the U.K., France, and Germany; Dialcom and GTE say they plan to provide X.400 services in the United States. DEC has implemented this standard over its corporate electronic mail system, and systems have been demonstrated by IBM, Northern Telecom (Mississauga, Ont.), Sperry (Blue Bell, Penn.), and ICL (London), among others. "By 1990, there won't be a single vendor who hasn't incorporated X.400 into its products," says Robert Mealy, western regional sales manager at Sydney Development (Vancouver, B.C.); his firm makes a commercial X.400 system for use with computers from several manufacturers, including IBM, DEC, and Tandem.

The second factor stimulating industry growth is the development of niche markets and value-added services. For example, Speed>S, a small Minneapolis company, markets a message system that transmits nontextual files, such as spreadsheets and computer programs, between desktop machines more cheaply than can be done by some of the major public networks; customers include the IRS, which frequently sends changes in taxation programs to its field offices, and accounting firms. Magnatex International (Annapolis, Md.) has piggybacked a specialized network over Dialcom's system oriented to public-relations and advertising firms. And in the private network arena, Fisher-Innis (Naples, Fla.) and ADR (Princeton, N.J.) offer message systems for IBM mainframes.

"While the X.400 standard will allow systems to interconnect, it is not sufficient to make the market grow," concludes Tony Caplin, managing director of AirCall, a British telecommunications firm. "The future of the industry depends as much upon our ability to develop applications and to train users effectively." □—***Stephen A. Caswell***

the information technology program at the University of Southern California. "It is more user-surly than user-friendly." But vendors are working on simpler interfaces, particularly for PC users.

Western Union, for example, has a software package called Instant Mail Manager, developed by Kensington Microware (New York). The package, which contains word processing, list management, file maintenance, and communications functions on a single floppy disk, allows a user of Western Union's EasyLink service to prepare mail off line with the word processor and send and receive mail automatically. The software package will call Easylink at a predetermined time, log on, transmit any prepared messages, scan the user's electronic mailbox, read and download any unread messages (to a floppy or hard disk), and log off. Electronic mail can then be read and rerouted at leisure. An extension to Instant Mail Manager, called Instant Forms Plus, lets EasyLink users design and transmit their own electronic business forms for applications such as order entry and invoicing.

Another popular software package, Transend PC from Transend Corp. (Portola Valley, Cal.), uses graphics to simulate a series of in- and out-boxes and files on the display screen. It also calls specified electronic mail services automatically, mailing letters and recording incoming mail on disk. The package has proved so easy to learn that it has been adopted and modified by several electronic mail services for use by their customers with PCs.

A more advanced alternative for executives and managers is GE's BusinessTalk system, a software package for the Apple Macintosh or the IBM PC and compatibles that combines electronic mail with database information retrieval and management and a private bulletin board system. According to Norman McBurney, manager of technical marketing at General Electric Information Services Co., BusinessTalk evolved from AppleTalk, a private system that the company developed for Apple to allow it to communicate with its dealers nationwide and around the world. In adapting this software to the IBM PC, GE has retained the Macintosh emphasis on graphic displays and easy interaction with the user.

McBurney describes BusinessTalk as a value-added service, one that provides more specific utility than basic electronic mail or remote computing service—and that presumably allows the provider to charge more for the service. Indeed, all the electronic mail services are anxious to pursue add-on applications. MCI Mail even has a "value-added reseller" program that lets independent companies provide applications and resell MCI's service.

WILLIAM HUBER

"Electronic mailboxes can talk," says Wang's Martha Danly, "but converting speech to text is tough."

Most of the public electronic mail systems are currently limited to transmitting text messages encoded in ASCII format—the American Standard Code for Information Interchange—which permits simple error checking and is relatively reliable for document transmission. This means that files in a more condensed binary format, such as computer programs or spreadsheet models, cannot be sent directly. GE's BusinessTalk system, however, has an error detection and correction protocol that can send binary files. Thus a user can develop a spreadsheet model or a Macintosh graphic and send the complete file to another user. The recipient can then work directly on the file and then return it to the sender for further modification. AT&T Mail has a similar binary file transfer facility.

In the future, electronic mail systems may be able to combine text, graphics, photographic images, spreadsheet models, and voice within a single message. At BBN Laboratories (Cambridge, Mass.), researchers have designed, and routinely use, such a multimedia system, called Diamond. Developed for the Defense Advanced Research Projects Agency, the system operates on a high-performance workstation, currently a model from Sun Microsystems (Mountain View, Cal.) that is capable of displaying and editing such multimedia documents. Terry Crowley, a BBN researcher working on the Diamond project, admits that the high cost of suitable workstations is an impediment to widespread use of multimedia systems, but he notes that workstation prices are now dropping (to as low as $10,000) and that the next generation of personal computers will be powerful enough to run such software.

Some aspects of multimedia mail are al-

SEALED WITH A SMILE

Among aficionados of electronic mail, a convention has arisen for indicating a joke: inserting "smileys," combinations of characters that, when turned 90°, look like tiny smiling faces. Some smileys we've seen:

:-) the standard smile

;-) a winking smile

B-) a smile with eyeglasses

8-) a smile with granny glasses

:@) a smile with a big nose

And then, of course, there is the opposite emotion :-(

—Jeffrey Bairstow B-)

A Trip To The Electronic Post Office

Because I work out of my home, I've been using an electronic mail service—MCI Mail—for the last couple of years in order to send text to (and receive text from) HIGH TECHNOLOGY's Boston office. In addition, it helps me to keep in touch with other writers and sources of information, and even to send letters to those unfortunate people who don't have an electronic mailbox. All my writing is done on a personal computer, so I compose drafts of letters—whether intended for electronic or hard-copy delivery—with a word processor and store them on disk. Not only is it much easier to edit with the word processor instead of on line to the electronic mail service, but I can transmit letters much faster directly from the disk and so save connection time (and money).

Generally, I check my mailbox once a day. My word processor (XY-Write) lets me call up my communications program (Perfect Link) directly. The latter has MCI Mail's phone number, my mail user name, and my confidential password stored in an automatic log-on sequence. The program dials MCI Mail through a modem, waits for an answer, and then logs me on without my intervention. MCI Mail responds with its own identification and a message telling me how many letters are in my mailbox. Usually there are four or five, but I've had as many as 30 on occasion.

At this point, most mail services offer a menu—scan the mailbox, read a letter, create a letter, and so on—but as an (ahem!) advanced user, I've opted for MCI's service that uses two-letter commands and dispenses with repetitious, boring, and time-consuming menus. To look at incoming mail, I type *SC* (for scan), which produces a numbered list of the letters in my in-box that shows the sender, the subject, the length (in characters), and the date and time of sending.

To look at a particular letter, I type *RE 1* (read letter 1). A header is displayed on the screen, giving the sender's name, MCI address, and affiliation, as well as the subject and the number of "carbon copies"—followed by the text, one screenful at a time. Short letters I often answer directly by using the command *AN* (answer), which automatically sets up a header with the recipient's name and my name (*To:*, *From:*, etc.), and then lets me type my reply directly. Longer letters or manuscripts from authors I store on disk with the *PR* (print) command, which scrolls a message across the screen without stopping, and the file capture routine in my communications software. I occasionally *FO*rward letters to other people for their attention, often with a short note of my own attached.

To send letters (other than replies), I use the *CR*eate command, which then asks the name of the recipient and checks the MCI Mail directory to see if that person is listed. If not, I have the option of sending a paper letter to a conventional mail address. MCI Mail has several paper mail options including four-hour or overnight delivery by courier service as well as delivery by USPS. In all cases, an electronic copy of my letter is sent to an MCI Mail center near the intended recipient and output by a laser printer using facsimiles of my letterhead and my signature.

I can type the text of a letter directly or I can send a prepared letter by calling up the file from a disk with my communications software. Letters are closed with a slash (/) on a new line, and MCI Mail then asks if I want to send the letter immediately. Usually I do just that, but I could also edit the draft further at this point using MCI's rather clumsy line-oriented editor. When a letter is posted, MCI also sends a copy to my electronic out-box, where it will stay for five days—a useful feature in case a letter gets garbled in transmission and needs to be re-sent.

When I've completed my mail, I *EX*it from MCI Mail, and my communications software returns me automatically to my word processor. A typical session with four or five letters to read and a similar number of brief responses might take 15–30 minutes. That's faster than going to my local post office and a lot more pleasant. But ironically, my bills don't come in electronic form—even MCI does its billing by snail mail.—***Jeffrey Bairstow***

ready starting to appear. Users of AT&T Mail can call the system with a push-button telephone and have their mail read to them by a speech synthesizer. A recently announced option with the Wang Office system offers the same feature. However, converting telephone speech messages into electronic text is "several years away," says Martha Danly, Wang's voice products planning manager.

As electronic mail spreads and the subscriber bases grow, the sheer quantity of computer-based messages could become overwhelming, says Thomas Malone, a professor at MIT's Sloan School of Management. Malone and his colleagues are working on a system called the Information Lens to help people filter, sort, and prioritize electronic messages. For example, a social filter might give high priority to messages from an immediate superior. Or an economic filter might give high priority to messages to which the sender had affixed the electronic equivalent of first-class postage.

Malone foresees intelligent electronic mail systems that might actually "read" the mail and take actions based on rules developed by individual subscribers. One example is the use of message templates for sending information about meetings. If the request to hold a meeting is sent in a standard electronic form, a system like the Information Lens could be set up to determine who should get the message, automatically check the recipient's calendar, update the calendar with the meeting date and time, advise the recipient of the calendar update, and notify the meeting organizer that the recipient has seen the message and can go to the meeting. Malone expects to add rules to the Information Lens so recipients of electronic mail can build their own filters for several types of messages.

Before multimedia and intelligent mail systems move out of the research environment, the number of electronic mail users must reach the critical mass that will "turn the business from a tough sell into a demand-pull industry," says *EMMS*'s Arnum. But the signs are all there: the suppliers of private electronic mail systems are emphasizing networking and connections to other vendors' systems; and the providers of public electronic mail services are finally recognizing the importance not only of connection to private systems but also of interoperation with each other. With the spread of PCs and desktop terminals, software is becoming easier to use and applications software is being developed to handle specific business needs. Already, some 5 million people have electronic mailboxes, both public and private, sending perhaps a couple of billion messages a year. And "there will be dramatic growth—60 billion electronic mail messages a year by the turn of the century," says Ulrich at Coopers and Lybrand. The critical mass, then, may not be far away.

Jeffrey Bairstow is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p.* **64.**

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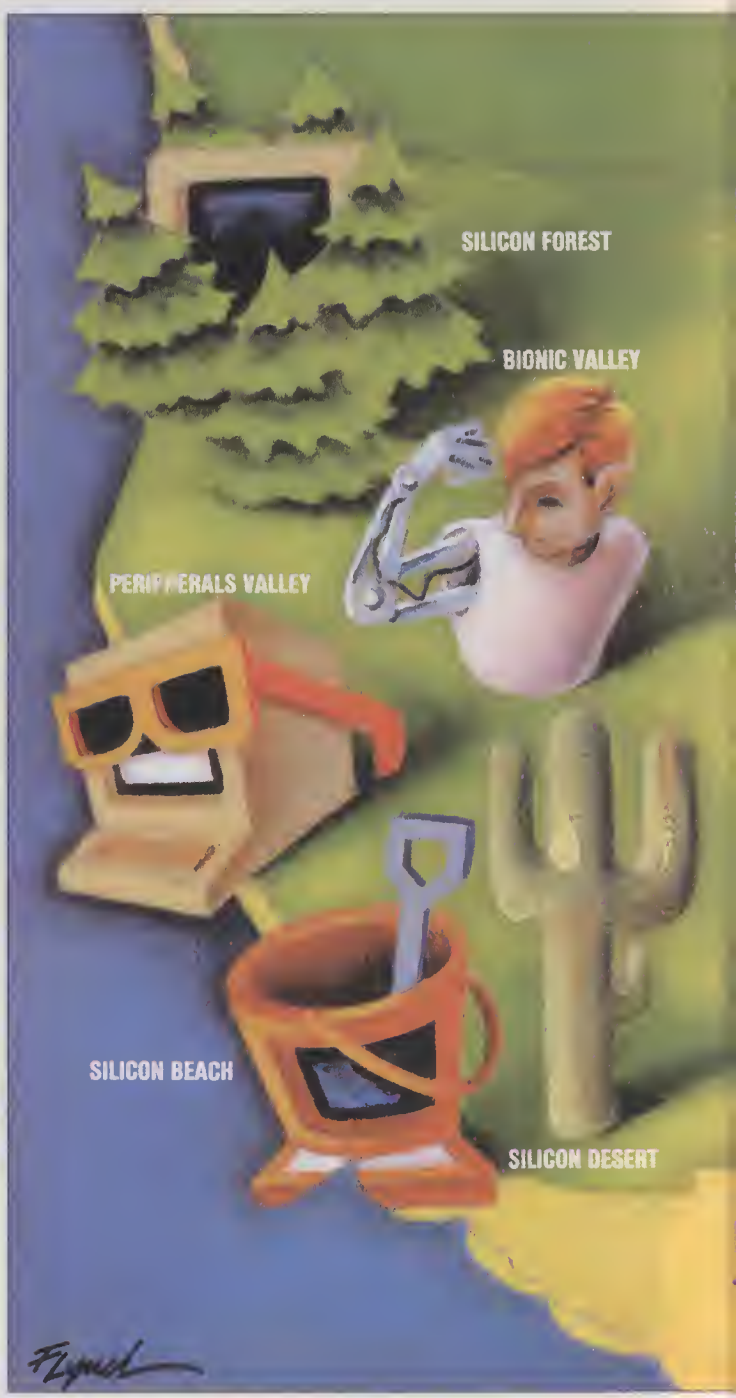

Regional developers throughout the U.S. are trying to duplicate the formula that turned Santa Clara County into a high tech haven

BY THERESE ENGSTROM

The name "Silicon Valley" has become synonymous with high technology development—and, until recently, with rapid economic growth and low unemployment rates. But although technology is not the recession-proof cash crop it was once perceived to be, many state and city officials elsewhere still consider it their ticket to success. Thus they continue to scour Silicon Valley to discover its secrets, and then apply their knowledge back in Indiana or Alabama or Manhattan in an economic version of reverse engineering.

As development authorities from various regions have studied the Silicon Valley model, four major elements have emerged. One is a strong, scientifically oriented university—in this case, Stanford—with a reputation for fostering research and facilitating ties between faculty and the business world. For example, Stanford permits faculty to keep a third of the net royalties from patents developed with university resources; the remainder is divided between the professor's school and academic department. By contrast, most institutions keep all such funds, giving faculty members little incentive to commercialize their inventions. In addition, Stanford faculty may go on leave to form their own companies and are allowed to consult for one out of every seven days. Stanford has also furthered university–industry collaboration through the Center for Integrated Sys-

ILLUSTRATION BY FRED LYNCH

tems, a research institute on semiconductor development to which dues-paying businesses may send visiting scholars.

A second factor in the development of the Valley has been the establishment of technology parks, which allow resident companies to take advantage of university resources while providing a base for faculty contract work. Stanford began construction on the first such site in 1951. The Stanford Research Park, still the only major university-affiliated park in the area, is now fully leased, with 90 companies, mostly in technology-related businesses, employing over 25,000 people.

Dollars have been a third important ingredient in the Silicon Valley mix, particularly funds derived from venture capital firms that provide seed money for the early stages of start-up companies. "The concept of venture capital was born on the East Coast," says William Barnum, a principal at Brentwood Associates (Los Angeles), which has helped fund a host of start-ups, including Apple Computer. "But there has been a gradual shift of firms toward the other end of the country." Of the 668 venture capital offices in the nation, 183 are now in California, according to *Venture Capital Journal* (Wellesley Hills, Mass.); such offices are defined as housing one or more of the firm's general partners.

The final element is a physical and cultural climate conducive to the lifestyle and business needs of risk-taking entre-

DEL BROWN

Wayne McGown, special assistant to the chancellor of the University of Wisconsin at Madison, provides liaison with the University Research Park.

DAVE WILDER

Ohio's Thomas Edison Program supports the research and funding needs of high tech firms, as well as the modernization of traditional companies, says executive director Christopher Coburn, shown here at the Edison Welding Institute.

GARY GOLD

RPI designated a campus building as a home for start-ups. Shown in foreground (left to right) are Jerome Mahone, director of the Incubator Program, and Kevin Ikeda and Eric Westbrook of Lync Systems, one of the companies assisted by the program. Lync makes a master keyboard for use with music synthesizers.

preneurs. Physically, the Valley provides a comfortable ambience, including moderate, Mediterranean-type winters, and the Pacific and the Sierra Nevada within driving range for weekend sports. Culturally, the region provides a social milieu that values innovation and reveres success, a political environment that supports economic policies favorable to the growth of small businesses, and a service sector—including law firms, accountants, and bankers—geared to the needs of entrepreneurs.

Although it's easy enough to identify the four main elements of the Silicon Valley model, it's not so easy to replicate them. "To have all these things in place is very rare; if you miss any one, you have problems," says David Birch, director of the program on neighborhood and regional change at MIT. "I can think of maybe four or five places in the country in addition to Silicon Valley—Boston, Austin, North Carolina's Research Triangle Park, and Pittsburgh—where all the elements are there." This, of course, has not inhibited many other areas of the country from attempting to extend the list by building any components of the Silicon Valley model that are not yet present, or strengthening what is already there.

First is the crucial factor of a core university. Not just any university will do, says James Howell, senior VP at the First National Bank of Boston. "Universities in the Midwest, for example, may be very good ones," he points out. "But they tend to turn out engineers—not 'deviates' who have the mindsets to start innovative, technology-oriented companies." Douglas Porter, director of development policy at the Urban Land Institute (Washington, D.C.) agrees. "The simple presence of a university won't be enough unless it has the bang of an MIT, a Princeton, or a Stanford."

In the past few years, several states have taken steps to enhance the general research capabilities of their public universities in order to bring them closer to the status of the MITs of the world. The Texas legislature, for example, in 1983 permitted the University of Texas at Austin to use income from its endowment fund to match gifts from the private sector for endowed chairs (costing a minimum of $500,000) and professorships ($100,000), among other categories. Such money is used to supplement a faculty member's salary and for research. As part of this campaign, 32 chairs in science and engineering were endowed at $1 million each. The university also strengthened its support of computer science and electrical engineering by adding 15 new faculty members in each area, increasing allocations for lab equipment by $5 million over two years, and stepping up graduate

student recruitment. These efforts were among several factors that led the Microelectronics and Computer Technology Corp. to locate in Austin.

The legislatures in Utah and Oregon have also taken steps recently to channel more research funds to their state universities. Utah has increased its subsidy of the University of Utah's indirect costs incurred in federally-sponsored research from 25% to 75%. And the legislature has indicated its intent to raise that portion to 95% in 1987. The Oregon legislature gave the University of Oregon incremental funding of $2 million to establish 12 new faculty positions in research areas of growing interest to the campus, including biotechnology, materials, computer science, and optics, and allocated $12 million for new science buildings.

In addition to fortifying traditional university activities, many states have also begun establishing specialized research institutes—usually called centers of excellence or advanced technology centers—to enhance particular applied research capabilities of local universities and stimulate university–industry research collaboration. Such centers, whose research programs usually draw on matching funds from corporate sponsors, expose firms to potential employees, enable faculty members to share expensive equipment, and provide for visiting-scholar arrangements with senior industrial scientists. The themes of these centers usually reflect both the existing program strengths of the host universities and the interests of businesses located in the state.

New Jersey's Commission on Science and Technology, for example, has formed advanced technology centers in such fields as biotechnology and medicine (located at the adjoining campuses of Rutgers University and the University of Medicine & Dentistry of New Jersey) and food technology (at Cook College, Rutgers's agricultural school); the choice of these subjects is directly related to the significant role played in New Jersey's economy by pharmaceutical and agricultural companies. The state has also established centers on hazardous and toxic substances (at the New Jersey Institute of Technology) and on plastics recycling (at Rutgers) to strengthen research relevant to New Jersey's notorious problems with some of the byproducts of technology. The hazardous-substances center, for instance, currently has 17 industry members, mostly from the petroleum, chemical, and electronics sectors; it carries out research projects on such topics as the incineration of hazardous wastes, biological and chemical waste treatment, and health effects of hazardous wastes.

The commission uses a fund of $57 million, derived from a bond issue passed in 1984, to support the capital needs of centers; operating costs are paid out of the state budget, contributions from host universities, and annual fees of $35,000 to $50,000 from corporate sponsors. Sponsors at each center participate in choosing and carrying out projects and have the first rights to any research results for one year.

The state of New York has a technology center program similar in scope and organization to that of its neighbor; this program has leveraged $50 million in private funds on top of $25 million in state money contributed to the centers since 1983. Located at both private and public universities, the centers cover such areas as computers and information systems (Columbia University), agricultural biotechnology (Cornell University), healthcare instruments (State University of New York at Buffalo), and optical technology (University of Rochester). Host institutions were selected not only on the basis of their record of achievement in the relevant technology, says John Deffigos, deputy executive director of the New York State Science and Technology Foundation, which administers the center program, but also because of their willingness and ability to carry out collaborative projects with industry.

In Pennsylvania, the state's Ben Franklin Partnership undertakes a variety of regional technology development programs through four advanced technology centers; these are located at Pennsylvania State University, Lehigh University, Philadelphia's University City Science Center, and the University of Pittsburgh. The centers do not carry out their own research, but solicit, administer, and provide challenge grants for proposals undertaken by cooperating institutions and businesses. Each center specializes in a number of research areas. Lehigh's North East Tier Advanced Technology Center, for example, funds R&D projects in CAD/CAM, microelectronics, materials, and biotechnology. As at other centers, a business must team up with an area college or university in submitting a proposal, and must match state funds for the project on a dollar-for-dollar basis.

The second factor deemed important to the creation of new Silicon Valleys has been the presence of technology or research parks near the core university or technology center (HIGH TECHNOLOGY, Jan. 1986, p. 48). Such parks serve as catalysts for bringing companies to an area conveniently located near the intellectual resources and research labs of a university, provide faculty members with consulting opportunities, and may even bring rental income to the university. For these reasons, the number of parks initiated by universities has grown rapidly over the last few years; some 200 currently exist or are being planned, according to the Association of University-Related Research Parks (Tempe, Ariz.).

"No single model describes the variety of management arrangements that have evolved between technology parks and their sponsors," says Mark Money, president of the parks association and director of the Texas A&M University Research Park. "However, universities usually own at least some of the land on which a park is built, and they usually retain some control over tenant selection." Tenants are generally favored who engage in administrative, research, testing, and prototyping functions, but not manufacturing.

University Research Park in Madison, Wis., has been under development since 1982 on farmland originally owned by the University of Wisconsin. The university sells this land piecemeal to a nonprofit organization, which in turn leases it to tenants and manages park operations. One company in the park is Warzyn, a research and engineering consulting firm involved with surface-water quality and waste disposal; this focus parallels research programs at the university on pollution of lakes. Persoft, a four-year-old firm founded by two former consultants to the university's computer science department, makes terminal emulation software that facilitates communication between different brands of computers. Sevrain Tech, a start-up involved with neuroprosthetic devices for the disabled, was attracted to Madison in large part because of the university's experience in related fields.

The Princeton Forrestal Center, home to 5000 employees and 50 tenants at a 715-acre site located between Philadelphia and New York City, is farther along in its development than the Madison park, and encompasses several hundred housing units and a conference center, as well as

It's easy enough to identify the four main elements of the Silicon Valley model, but only a handful of other locations in the country have all the elements in place.

SOME ASPIRING HIGH TECH MECCAS

KEY:

a. Major universities
b. Research parks
c. Region's main technological focus
d. Examples of state programs

*Under development

ALABAMA: HUNTSVILLE

a. Univ. of Alabama/Huntsville
b. Cummings Research Park
c. Optics, aerospace, robotics, electronics, telecommunications
d. Alabama High Technology Assistance Center, Center for High Technology Management & Economic Research, Small Business Innovation Research Programs

ARIZONA: PHOENIX/TEMPE

"Silicon Desert"

a. Arizona State Univ., Univ. of Phoenix
b. Arizona State Univ. Research Park
c. Microelectronics, computer science, CAE, energy systems, CIM
d. Engineering Excellence Center Program, Office of Economic Planning & Development Programs

CALIFORNIA: LOS ANGELES/ ORANGE COUNTY

"Peripherals Valley"

a. Univ. of California/Irvine, Univ. of California/Los Angeles, California Inst. of Technology, Cal. State/Long Beach, Cal. State/Fullerton, Cal. State/L.A.
b. University of California Irvine Park
c. Computer science, software, peripherals, aerospace, automated manufacturing, microelectronics, biotechnology
d. Manufacturing Engineering Program, Software Productivity Program, The California MICRO Program (funding for joint industry–university research projects in microelectronics and computer science)

CALIFORNIA: SAN DIEGO

"Silicon Beach"

a. Univ. of California/San Diego, San Diego State Univ.
b. Univ. of California San Diego Park*
c. Microcomputers, biotech, microelectronics
d. Supercomputer Program, The California MICRO Program

COLORADO: COLORADO SPRINGS/ DENVER/BOULDER

"Silicon Mountain"

a. Univ. of Colorado at Boulder, Colorado Springs, & Denver
b. Univ. of Colorado Research Park*
c. Microelectronics, optoelectronics, materials, aerospace, telecommunications, biotechnology, computer peripherals
d. Colorado Advanced Technology Institute (Centers of Excellence Program), Governor's High Technology Cabinet Council

CONNECTICUT: NEW HAVEN/ FAIRFIELD COUNTY

a. Yale Univ., Central, Southern & Western Connecticut State Colleges, Univ. of New Haven
b. Science Park (New Haven)
c. Metals, chemicals, biotechnology
d. Connecticut Product Development Corporation, Connecticut Innovation Development Program, Technology Investment Fund

FLORIDA: GAINESVILLE TO ORLANDO

"Robot Alley"

a. Univ. of Central Florida/Orlando, Univ. of Florida
b. Central Florida Research Park; Univ. of Flordia Research & Technology Park
c. Robotics, simulation, aerospace, lasers, optics, microelectronics, materials
d. Florida High Technology and Industry Council (Centers of Excellence Program), High Technology Innovation Board

FLORIDA: TAMPA

a. Univ. of South Florida, Univ. of Tampa
b. Tampa Technology Park*
c. Microelectronics, aerospace, software, medical technology, chemicals
d. Florida High Technology and Industry Council (Centers of Excellence Program), High Technology Innovation Board

SOUTHEAST FLORIDA

"Silicon Beach"

a. Univ. of Miami, Florida Inst. of Technology (Melbourne), Florida Atlantic Univ. (Boca Raton)
b. Biomedical Research & Innovation Center (Miami), Florida Atlantic Univ. Research Park*
c. Electronics, robotics, biomedical, aerospace
d. Florida High Technology and Industry Council (Centers of Excellence Program), High Technology Innovation Board

GEORGIA: ATLANTA

"Technology Crescent"

a. Georgia Institute of Technology, Georgia State Univ., Emory Univ.
b. Advanced Technology Development Center (Georgia Tech)
c. Software, telecommunications, aerospace, microelectronics
d. Advanced Technology Development Institute, Advanced Technology Development Center, Georgia Research Consortium

ILLINOIS: CHICAGO

a. Univ. of Illinois/Chicago, Illinois Inst. of Technology, Univ. of Chicago, Northwestern Univ.
b. Evanston/Univ. Research Park, Chicago Technology Park
c. Biotechnology, pharmaceuticals, software, supercomputers, electronics, ceramic engineering
d. Governor's Commission on Science & Technology, Technology Commercialization Centers Prog., Business Innovation Fund, Illinois Venture Fund, Small Business Innovation Research Prog., Illinois Center for Industrial Technology

INDIANA: INDIANAPOLIS/LAFAYETTE

a. Purdue Univ., Indiana Univ./Indianapolis, Indiana Central Univ.
b. Purdue Industrial Research Park
c. Medical technology, biotechnology, software, manufacturing technologies
d. Indiana Corporation for Science & Technology, Corporation for Innovation Development, Institute for New Business Ventures

LOUISIANA: LAFAYETTE

"Silicon Bayou"

a. Univ. of Southwestern Louisiana
b. Northpark High Technology Center
c. CAD/CAM, computer science, petroleum engineering, telecommunications
d. Louisiana Innovation Ctr., Louisiana Small Business Devel. Corp., Enterprise Zone Program

MARYLAND: BALTIMORE

a. Univ. of Maryland/Adelphi, Johns Hopkins Univ., Univ. of Baltimore
b. Maryland Science Technology Center
c. Biomedical technology, telecommunications, aerospace, software
d. Engineering Research Ctr., Ctr. for Advanced Research in Biotechnology, Maryland Biotechnology Inst., Enterprise Development Fund

Analysts attribute Silicon Valley's success to several different factors, including a strong university linked to a research park, and state development programs that encourage technological innovation. Listed above are some of the regions that are following a similar model for growth. (Massachusetts's Route 128 is excluded because it has already attained the status of its California counterpart.) The table was compiled by Margaret Woisard.

office space. Forrestal is owned by Princeton University, which turned over management to a private firm, K. S. Sweet Associates. Among companies at Forrestal attracted by Princeton's reputation in such fields as electrical engineering and biomedical science are Siemens, which maintains its North American research center for microelectronic research there; Liposome, which is working with naturally occurring substances that can alter the ways in which drugs are released and distributed in the body; and Cytogen, which focuses on the use of monoclonal antibodies for diagnosis and therapeutics.

The University of Michigan has a somewhat different relationship with the Ann

Michigan: Ann Arbor
"Automation Alley"

a. Univ. of Michigan, Eastern Michigan Univ.
b. Ann Arbor Technology Park, Geddes Center
c. Manufacturing technologies, robotics, biotechnology
d. Bureau of Innovation and Technology (Centers of Excellence Program), Michigan State Research Fund

Minnesota: Minneapolis/St. Paul
"Medical Alley"

a. Univ. of Minnesota
b. Minnesota Technology Corridor
c. Supercomputers, biotechnology, medical technology, software
d. Office of Science & Technology, Minnesota Technology Corridor Corporation, Minnesota Project Innovation, Minnesota Wellspring

New Jersey: Princeton

a. Princeton Univ.
b. Princeton Forrestal Center
c. Telecommunications, electronics, biotechnology, aerospace
d. Commission on Science and Technology (Advanced Technology Centers Program)

New Mexico: Sante Fe To Albuquerque
"Rio Grande Research Corridor"

a. Univ. of New Mexico, Univ. of Albuquerque
b. Univ. of New Mexico Research Park
c. Computers, materials, lasers, plant genetic engineering
d. Centers of Excellence Program, New Mexico Business Development Corporation, New Mexico Energy Research & Development Institute, Technological Application Center

New York: Schenectady/Troy

a. Rensselaer Polytechnic Institute
b. Rensselaer Technology Park
c. Telecommunications, CAD/CAM, biomedical engineering, computer science
d. New York State Science & Technology Foundation (Centers for Advanced Technology Program), Corporation for Innovation Development, Incubator Program at RPI

New York: Long Island
"Tech Island"

a. State Univ. of New York at Stony Brook
b. Center for Advanced Technology in Medical Biotechnology
c. Medical biotechnology, electronics, aerospace
d. New York State Science & Technology Foundation (Centers for Advanced Technology Program), N.Y. Corp. for Innovation Development

North Carolina: Durham/Raleigh/Chapel Hill
"Research Triangle"

a. Univ. of North Carolina at Chapel Hill, Duke Univ., North Carolina State Univ., North Carolina Central Univ.
b. Research Triangle Park
c. Microelectronics, fiber optics, biotechnology, pharmaceuticals
d. Research Triangle Institute, North Carolina Board of Science and Technology's Innovation Research Fund, N.C. Technology Development Authority

Ohio: Columbus

a. Ohio State Univ.
b. Applied Information Technologies Research Center
c. Robotics, database management, chemicals
d. Thomas Edison Prog. (Centers of Excellence), Ohio Development Financing Commission, Ohio Technology Transfer Org.

Oregon: Portland To Eugene
"Silicon Forest"

a. Univ. of Oregon, Oregon State Univ., Portland State Univ., Oregon Health Sciences Univ., Oregon Graduate Ctr. (Beaverton)
b. Oregon Graduate Center Science Park, Sunset Research Park (Corvallis), Riverfront Research Park/Willowcreek Park (Eugene)
c. Microelectronics, CAD/CAM, lasers, software, electronic instrumentation
d. Oregon Resource & Technology Development Corporation, Oregon Center for Advanced Technology Education, Centers of Excellence Program

Pennsylvania: Pittsburgh
"Software Valley"

a. Carnegie-Mellon Univ., Univ. of Pittsburgh
b. Advanced Technology Center of Western Pennsylvania, Pittsburgh Technology Center*
c. Software (AI), computers, robotics, materials, biomedical technology
d. Ben Franklin Partnership (Advanced Technology Centers Program), Center for Entrepreneurial Development at CMU, Univ. of Pittsburgh's Foundation for Applied Science & Technology

Pennsylvania: Philadelphia

a. Univ. of Pennsylvania, Temple, Drexel
b. Advanced Technology Center of Southeastern Pennsylvania, Univ. City Science Center
c. Sensor technologies, space, biotechnology, materials
d. Ben Franklin Partnership (Advanced Technology Centers Program), Pennsylvania's Industrial Development Authority

Tennessee: Knoxville/Oak Ridge
"Technology Corridor"

a. Univ. of Tennessee (Oak Ridge National Labs)
b. Technology Corridor*
c. Materials, energy research (spinoffs from nuclear technology), biotechnology
d. The Tennessee Technology Corridor Foundation

Texas: Austin
"High Tech Hills"

a. Univ. of Texas
b. Balcones Research Center
c. Microelectonics, software, defense electronics
d. Center for Technology Development & Technology Transfer

Texas: Dallas/Fort Worth
"Silicon Prairie"

a. Southern Methodist Univ., Texas Christian Univ., Univ. of Texas/Arlington, Univ. of Texas/Dallas
b. Advanced Robotics Research Institute*
c. Electronics, robotics, factory automation, software, computers
d. Center for Technology Development & Technology Transfer, The Mayor's Task Force on High Technology (Dallas)

Utah: Salt Lake City
"Bionic Valley"

a. Univ. of Utah, Brigham Young Univ.
b. Univ. of Utah Research Park
c. Bionics, biomedical technology, biomaterials, CAD/CAM
d. Centers of Excellence Program, Utah Innovation Center, Utah Technology Finance Corporation

Virginia: Fairfax County

a. George Mason Univ.
b. Center for Innovative Technology
c. Telecommunications, software, biotechnology, CAE, data communications
d. Center for Innovative Technology Program

Washington: Seattle/Bellevue
"Software Alley"

a. Univ. of Washington, Seattle Univ.
b. The Washington Technology Center
c. Software, aerospace, biotechnology, microelectronics, materials
d. Council for Technology Advancement, Washington Research Foundation

Wisconsin: Madison

a. Univ. of Wisconsin at Madison
b. Univ. Research Park
c. Materials, medical imaging technology, supercomputers, microelectronics
d. Wisconsin Alumni Research Foundation, Wisconsin Innovation Service Center

Arbor Technology Park. Although adjacent to the University, the land for the park was privately owned by Richard Wood & Co., a local real estate developer. Approached by the university to use his land for a technology park, Wood agreed that this concept was a good theme for attracting desirable tenants, according to Jeff Knight, VP for park operations at the firm. The university participates in master planning for the site and in approving tenants. Several companies at the park undertake research reflecting university work on automotive technology and manufacturing productivity—areas of particular strength at the University of Michigan. For instance, Applicon, a divison of Schlumberger, is involved with CAD/CAM

Jeff Knight (seated) and Richard Wood are private developers who built and now operate the Ann Arbor Technology Park adjacent to the University of Michigan.

The Connecticut Product Development Corp. has received an 18% rate of return on its investments, says VP Burton Jonap (left), with Ed Randall, VP of Network Control, a telephone test equipment firm aided by CPDC.

JIM BROWN

Donald Plummer, director of research and communications at Georgia Tech's Advanced Technology Application Center, holds a computerized chart produced by Erdas, one of the companies housed at the center. Erdas makes image processing and geographic information systems.

CHUCK ROGERS

products, while both Toyota Motor Sales and Mazda maintain research facilities concerned with vehicle emission control; Mazda also does research on materials, drive trains, and automotive electronics.

If a park lacks a great university nearby, it may be able to find one willing to set up a "branch office." When Montgomery County, Md., officials conceived of R&D Village—a 1200-acre biotechnology research complex that will eventually consist of research facilities, housing, hotels, shopping centers, and a health club—they recognized that a major academic presence was lacking, even though the complex was to be anchored by the Shady Grove Life Sciences Center, home to several government research agencies. So the Montgomery County office of economic development convinced several institutions to initiate programs at the site: Johns Hopkins University is represented by a teaching facility, while the University of Maryland and the National Bureau of Standards have jointly established a Center for Advanced Research in Biotechnology, specializing in protein engineering and drug design. "We believe that such an institution will make it more desirable for companies to be here," says L. James Eaton, the county's economic development director.

In addition, or as a prelude, to technology parks, some universities have established high tech incubators that provide new companies with relatively low-cost office and lab space and access to related business services. One of the first incubators was set up in 1980 by Rensselaer Polytechnic Institute (RPI) in Troy, N.Y. "In looking for a way to promote business in this region and to provide more consulting opportunities for the faculty, we hit upon designating one of the campus buildings as a home for newly hatched companies," says Jerome Mahone, director of the Incubator Program. Companies that have emerged include Testamatic, which went public at an early stage with its automatic test equipment for printed circuit boards, and BioReactor Technology, which invented a continuous biochemical reactor for making monoclonal antibodies.

Down south, meanwhile, companies working in technologies ranging from electronics to biotechnology are housed in the $6.1 million Technology Business Center of the Advanced Technology Development Center (ATDC), located at the northern edge of the Georgia Tech campus. Most of the 77 companies that have been hatched in the center's two incubator buildings reflect the main strengths of the university—electronics (including telecommunications, software, and peripherals) and aerospace. The incubator, which works closely with the state's eco-

nomic development council, provides young companies with a range of support services, including assistance with business planning and contacts in the Atlanta business community for accounting, financial, legal, and other advice.

Even if the university is there and the business community is willing, a third necessary ingredient is money—particularly the venture capital that a new firm may need to get off the ground and bring a product to market. One problem suffered by would-be Silicon Valleys in the heartland is that venture capital tends to concentrate near the coasts. In 1985, 44% of the $2.6 billion in all venture capital went to California; two-thirds of that amount was concentrated in the northern section of the state, according to *Venture Capital Journal.* Another 13% of the total went to Massachusetts, and Texas took third place with 6%.

Which comes first—ready venture capital or a technology center—seems to be a chicken-or-egg question. But venture capitalists admit that geographical nearness is important. "We're early-stage investors," stresses George McKinney, a general partner at American Research & Development in Boston. "You can't undertake an investment if you're not within a quick trip of the company, because you'll usually visit once or twice a week at that stage." Thus the firm has funded generations of companies—including Digital Equipment, Teradyne, and Symbolics—near its Boston base. "There's definitely a bias toward companies that are close to home," agrees Barnum of Brentwood Associates. "I wouldn't want to say that we'd never do a deal more than 50 miles away, but you won't get a guy to fly to Biloxi, Mississippi, from Los Angeles every week. It's too time-intensive."

Some universities and public bodies have begun to imitate the risk-taking activities of venture firms, drawn by the reward of potentially large returns and the hope that private venture money will be attracted to companies or areas receiving state support. States also want to aid smaller firms whose relatively modest financial needs may not be addressed by the private venture community. Public venture funds usually consist of corporate contributions, applied against some proportion of the donor's state taxes, or some fraction of state pension funds.

In Maine, the Maine Capital Corp. (MCC) in Portland has been "a catalyst in finding deals for the state and getting them in front of the institutional investors," says David Coit, MCC's president. MCC is a privately owned company that has formed a $2 million investment fund; $1 million of that was raised from banks and companies, which were permitted by state law to receive a 50¢ credit against their state tax liability for every $1 invested in MCC. Before the inception of MCC in 1980, Coit says that no more than $2 million in professionally managed venture funds had found its way to the Maine market; since then, over $40 million in venture capital has been invested in Maine. Firms funded by MCC include Agritech Systems (Portland), which makes monoclonal antibody–based diagnostic products for poultry and cattle; Shape (Biddeford), a maker of audio cassettes, video cartridges, and compact discs; Wright Express (Portland), which markets software and communications systems for a network of automated gas pumps; and Ocean Products (Eastport), an aquaculture firm that raises Atlantic salmon in pens.

Taking a different approach, the New York State Legislature has permitted two of the state-administered pension funds to allocate up to 5% of their $60 billion in assets to previously disallowed investments, such as high tech start-ups. Over the past three years, this has made $60 million in venture money available to the New York State Business Partnership, an entity managed by the private firm of Rothschild Ventures (New York). Although some 30% of the nation's private venture money is concentrated in New York State, says Douglas Luke, a partner in the firm, relatively little of it has been used within the state. "We hope to change that picture."

So far, a total of $35 million has been invested in deals in which Rochschild has participated, including $10 million in Partnership money and $25 million in external funds. As with the Maine Capital Corp., Partnership funds may be invested in any type of business, but technology-related firms dominate. These include Market Vision (New York), which produces a high-resolution graphics system for commodity and stock trading; Commercial Software (New York), a company that markets software products to help large corporations manage their telecommunications systems; and Protein Databases (Huntington Station), whose products aid in the precise analysis of proteins in blood samples.

Connecticut has taken the venture approach one step farther, investing money for up to 60% of the cost of developing products—from concept to marketing (excluding the cost of production line equipment). The Connecticut Product Development Corp. (CPDC) in Hartford, unlike traditional venture firms, does not take an equity position in the companies it supports. Instead, it receives royalty payments on sales of the product aided until a certain level is reached (generally a multiple of the investment). CPDC funds come from state general obligation bonds and money plowed back from earlier successful investments.

Eighteen of the 72 products supported by CPDC since 1975 are currently in development, and 25 are being marketed; the organization now has $15 million in outstanding investments and has achieved a respectable 18% rate of return on past investments. "We plan eventually to be operating on a self-sustaining basis," says VP Burton Jonap. Companies assisted in the past two years include Chimerix (Farmington), which is developing an immunoassay system; Consolidated Controls (Bethel), working on mobile robotic vehicles; and International Biotechnologies (New Haven), which is developing DNA sequencers, software, and other products for molecular biology research.

Some regions hope to compensate for any weaknesses in the first three elements of the Silicon Valley model by pointing to strengths in the remaining area—the general "climate." "You have to have a place where bright people want to come and stay," says MIT's Birch.

One problem suffered by would-be Silicon Valleys in the heartland is that venture capital tends to concentrate near the coasts. Last year, 44% of all such funds went to California.

Several states, including Oregon, Washington, Colorado, and Vermont, have stressed the amenities offered within their borders. For example, Vermont development officials, who followed Maine's lead in sponsoring a venture capital fund, brush aside the frequent complaint that the state is geographically isolated from major markets. Telecommunications may obviate that issue, says Roberta Harold, deputy commissioner of Vermont's office of economic development. Besides, quality of life is more important, she says. "Many of our businesses are started by second-home owners who say, 'Why should I put up with the rat race when I can live in a beautiful area, where I can breathe clean air, and my children will be safe?' "

"Climate" also means the extent to which a state is perceived as friendly to business interests—particularly when it

comes to taxation. The desire to provide a good business environment has led many states to revise some of their tax legislation or to retain provisions considered advantageous in attracting businesses.

Oregon, for example, made itself more hospitable to firms having substantial overseas operations by abolishing its worldwide unitary tax law in 1984; instead of defining a corporation's taxable income as a proportion of the earnings of the parent company and all its subsidiaries, Oregon now bases its taxes on U.S. profits only. Several states, including New York and Utah, offer R&D tax credits to local businesses. Minnesota allows a company to offset its state taxes with credit equal to 30% of the net value of technology donated by the firm (up to $300,000) to a certified small business in the Minnesota Technology Corridor, a section of Minneapolis located between the downtown area and the University of Minnesota. The intent of this policy is to encourage large corporations to transfer concepts and new technological developments to smaller firms that may be more interested in commercializing them. And a few states, such as Texas and New Hampshire, lure businesses by forgoing certain broad-based taxes; in Texas, there is no personal or corporate income tax, and New Hampshire elects governors who "take the pledge" not to implement a sales or personal income tax.

However, MIT's Birch warns that "climate" is not created by low taxes alone, and that they can even be a hindrance. Unless the local government provides services such as good police protection, good roads, and good schools—and isn't afraid to tax to get them—the locale can forget any dreams of being a high tech mecca. Porter of the Urban Land Institute also stresses that "like any real estate development, location is key. A high tech area needs to be marketed, but it also needs good highways, access to major markets, transportation networks, and good residential neighborhoods."

Even as states compete intensely to create Silicon Valleys, some observers are warning that the results might not be panaceas for local economic problems. "High tech firms have been slowing down as job creators," says Birch, who blames overseas competition for the decline. Considering that electronics employment in the U.S. fell by 100,000 people from December 1984 to June 1986, "technology can't be seen as the endless ramp it was in the 1970s."

In those places where a miniature Silicon Valley has taken hold, some fear their dependence on a monolithic economy. In Vermont, for instance, it's estimated that makers of electrical machinery and fabricated metal now employ 34% of manufacturing workers—many of them in the far northwestern corner, where IBM looms large with an 8000-person plant in Essex Junction, and where the strength of the University of Vermont campus and the attractiveness of the Burlington area add to the pull. But Vermont officials remember that in 1949 the textile industry employed one out of every eight factory workers in the state. When textiles pulled out, the result was serious dislocations. Today textiles employ fewer than one out of 50 workers.

Thus, to ensure that all their eggs aren't put in one basket, many states are also using their high tech programs to promote the productivity of existing old-line industries. Such a strategy serves to protect the state against overreliance on newer sectors and to save, if not increase, jobs in once dominant industries.

Ohio's Department of Development, through the Division of Technology Innovation, has evolved a representative set of programs over the past 10 years intended to push the diffusion of technology from the lab to the business world. One component is the Ohio Technology Transfer Organization, a network of 26 agents located at community and technical colleges throughout the state. Among other functions, agents in the program—which is modeled after the agricultural extension service—help companies utilize the best technology available in their manufacturing operations by providing advice and by brokering the services of outside experts.

Another component is Tie-In, an on-line technical information and exchange database that maintains files on such topics as research interests of faculty members at Ohio campuses, R&D facilities in the state, and patents owned by Ohio firms. And under the Thomas Edison Program, matching grants are made to companies for projects in applied research and product development; for example, funds have been awarded for work on computerizing plastic extrusion and the construction of a continuous x-ray scanner that can analyze each part coming down an assembly line.

Ohio has not closed its doors to high tech start-ups, stresses Christopher Coburn, executive director of the Edison Program. "But our technology transfer activities let us cover our bets by balancing the needs of new firms with the modernization support required by companies involved in heavy manufacturing."

Pennsylvania's Ben Franklin Partnership encourages the implementation of advanced technologies such as robotics and CAD/CAM in existing businesses through the work of the state's technology centers. "We believe that technology can be introduced into traditional businesses like coal and steel, which are still an important part of Pennsylvania's economy," says Cindy Bowes, press secretary for the state commerce department. New York State's Productivity Development Program provides matching funds of up to $50,000 each to industrial firms for feasibility studies on adopting existing technology to improve their manufacturing productivity; for example, Dahlstrom Manufacturing, a sheet-metal producer in Jamestown, is using a $20,000 state award to study the use of robots to drill computer frames. And Michigan's Industrial Technology Institute (Ann Arbor)—an independent entity created by the state in 1982—carries out internal and contract-based research on advanced manufacturing technology, shop-floor communications networks, and the social and economic impact of automation. One recent project helped an automotive supplier develop automated equipment to test the components it produces, as well as to diagnose any problems.

"The lesson is that states and local governments shouldn't emphasize a specific high technology industry," says Paul Phelps, a policy analyst at the congressional Office of Technology Assessment, "because today's high tech is tomorrow's low tech." Instead, he says, the emphasis should be on "the process of technological innovation. The trick is to make sure there's a constant flow of technology into existing industries."

And just as the Silicon Valley route shouldn't be followed to the exclusion of other options for bolstering state economies, neither should it be overlooked. "By themselves, high technology firms tend to create relatively few new jobs," says Phelps. But over the years, they result in thousands of jobs in the general economy as they create new industries.

To ensure that all their eggs aren't put into one basket, many states are using their high tech programs to improve the productivity of existing old-line industries as well.

Therese Engstrom is a freelance writer based in Taunton, Mass.

For further information see **RESOURCES**, *p. 64.*

DOWN (BUT NOT OUT) IN THE VALLEY

The slump in semiconductors has taken its toll on Silicon Valley, but the region's intellectual and financial resources could fuel a recovery

BY SABIN RUSSELL

CHUCK O'REAR, FROM "HIGH TECHNOLOGY WINDOW TO THE FUTURE"

Silicon Valley may be the envy of economic planners throughout the world, but for the people who live and work in Santa Clara County, at the south end of San Francisco Bay, last year was the most unsettling period in memory. When the computer industry began to sputter two years ago, the Valley braced itself for one of those annoying slips that have occasionally dimmed its glitter. But now it is clear that this was no ordinary stumble: the recovery expected in 1986 never happened.

"There is a lot of quiet grief here," observes Wilfred Corrigan, chairman of LSI Logic, a Milpitas chip maker. Corrigan is one of the fortunate. Until September, his six-year-old company was able to stay profitable through the downturn. Others haven't been so lucky. Telmos, a Sunnyvale maker of chips similar to LSI Logic's, shut its doors this past fall after it could no longer sustain its losses.

In the two years preceeding September 1986, the region lost over 17,500 high technology jobs, according to the Califor-

The Valley has the nation's hightest vacancy rate in industrial real estate: 34%.

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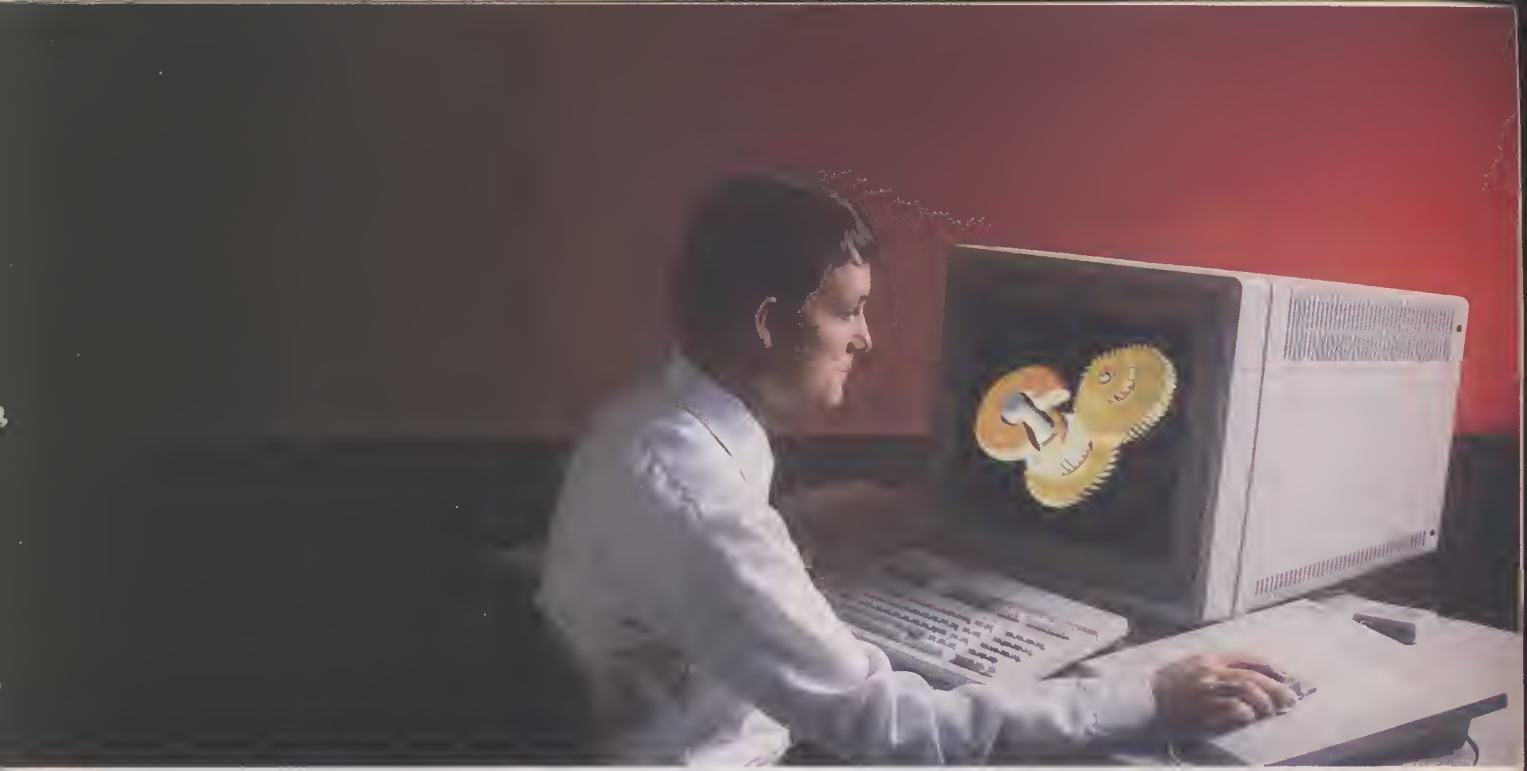

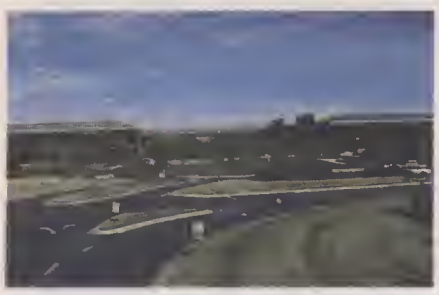

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nia Employment Development Department; many of these jobs were shipped to the cheap labor pools of Taiwan, Hong Kong, and Korea. Continuing growth in the service sector made up for all the lost jobs, but the Valley's fabled economic strength has clearly been diminished.

Lackluster growth has hardly turned Silicon Valley into a ghost town. The region's unemployment rate of 5.5% is still better than the national average of 6.8%. Its entrepreneurial culture remains vibrant. Venture capitalists pumped at least $426.5 million into young San Francisco Bay area businesses during the first half of 1986, according to a survey by the *San Jose Mercury News*. But for a region that prides itself on its world leadership—on a vision of academic, economic, and technological superiority—the dashed hopes of 1986 are disturbing.

Nowhere are the overturned expectations in Silicon Valley more apparent than in the numerous empty R&D complexes built by developers betting on a continued electronics boom. A recent study by realtor Grubb & Ellis (San Francisco) shows Silicon Valley leading the nation with a staggering 34% vacancy rate among its 95 million square feet of industrial real estate.

The figures do not include unused space already rented or owned by companies awaiting an upturn. In 1983, National Semiconductor made plans to build a $75 million R&D center next to its headquarters in Santa Clara. Three years later, with National smarting from a fiscal 1986 operating loss of $129 million in its Semiconductor Group, the completed building remains virtually unoccupied.

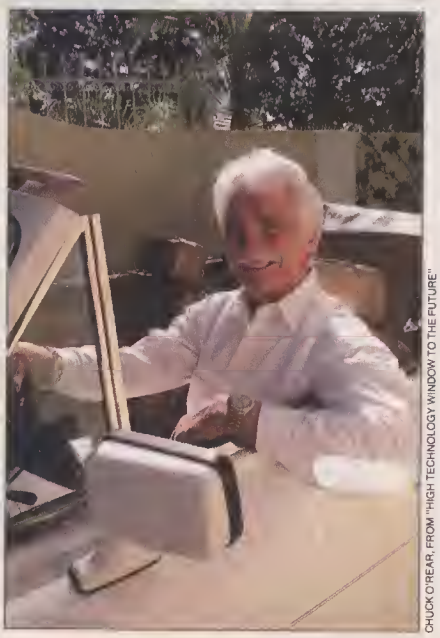
It was the semiconductor industry that gave Silicon Valley its nickname, and the current malaise in the Valley is a reflection of the hard times facing American chip makers. According to the Semiconductor Industry Association, the value of worldwide chip shipments in 1986 was expected to show an increase of only 6.5% over the previous year after taking currency fluctuations into account. That's a meager recovery from a disastrous 1985, when world microchip sales plummeted 17%. One of many companies hurt by the slump has been semiconductor manufacturer Advanced Micro Devices (AMD) in Sunnyvale, which in fiscal 1985 came within a whisker of $1 billion in sales, but saw its revenues drop to $576 million the following year. In October, after six consecutive quarterly operating losses totaling $149 million, the company dumped its no-layoff policy, idling 500 workers.

The Valley has also been hit hard by competition from Japanese firms. Japan's share of the $10.3 billion U.S. semiconductor market was estimated at 13.4% in 1986, up from 7.9% of the $6.27 billion market in

Too many semiconductor firms opened shop in the past few years, says Intel's chairman, Gordon Moore.

CINDY CHARLES

Richard Carlson, VP at QED Research, expects Valley firms to continue their world leadership during the next decade.



CHUCK O'REAR, FROM "HIGH TECHNOLOGY WINDOW TO THE FUTURE"

AMD has located new plants in Texas, where people tend to stay on the job longer than those in California, says chairman Jerry Sanders.

1981, according to Dataquest, a San Jose market research firm. More ominous has been Japan's penetration of particular niches. By the end of 1985, Japanese companies had garnered 55% of the $759 million U.S. market for dynamic RAMs, the workhorse memory chips used by most computer systems.

In a telling example of changing fortunes, Japan's Mitsubishi Metal recently agreed to purchase Siltec, the only American manufacturer of silicon wafers still headquartered in Silicon Valley. Wafers are the raw material out of which semiconductor chips are made. Siltec accepted a sale price of $33 million after suffering six consecutive quarterly losses. The firm had already moved most of its production to Salem, Ore., citing cheaper electric rates and lower labor costs.

Some of the Valley's problems are of its own making. In the early 1980s, venture capitalists and investment bankers "massively overfunded" small, high-growth companies such as semiconductor firms, according to a report by Robertson, Colman, & Stephens, a San Francisco investment bank. With too many suppliers pursuing the same markets, the stage for the current shakeout was set. Gordon Moore, Intel's chairman, agrees that "overventuring" harmed the semiconductor industry. "So many companies were set up to do the same thing as established firms that they didn't have any leverage. This probably weakened the overall U.S. semiconductor sector." Many Valley companies, buttressed by years of rapid growth, may also have become too complacent about their leading positions in the industry to look out for rising competition from more efficient and aggressive overseas firms.

In addition, the economics of the global electronics industry has contributed to the Valley's problems by pitting American semiconductor companies against their customers. Fighting back against alleged dumping of chips by Japanese companies at prices below their fair market value, American semiconductor firms pressured the U.S. and Japanese governments to establish a worldwide floor on the price of key components like the 256K RAM chip. "But this action has increased prices by at least $1 to $2 for each 256K

chip," says William Harris, VP for manufacturing at Convergent (San Jose). "This price rise may hurt computer manufacturers who use large quantities of such chips and whose profit margins are already thin." Such companies might have to go offshore to reduce their manufacturing costs, further cutting U.S. electronics jobs, he adds.

In any case, Valley companies may be losing out to their Japanese counterparts largely because of their lower productivity, according to a study prepared for the state legislature by SRI International (Menlo Park). "Japanese firms continue to have lower capital and labor costs, and have developed and implemented manufacturing processes which allow them to produce some semiconductors at half the cost of U.S. producers," the report says.

Ironically, the Valley's very successes in the past have contributed to its current problems. For example, the propensity of California's high tech workers to jump from job to job has discouraged some companies from building or keeping plants in the state. Long before AMD hit on hard times, chairman Jerry Sanders had launched a policy he called the Texas Tilt, locating new plants in Austin and San Antonio. "The key to success is low employee turnover," he maintains, "and people in Texas tend to stay on the job longer than those in California."

High housing costs, resulting in large part from the Valley's halcyon days, now make it difficult to attract and keep young engineers. For example, a single-family, two-bedroom home in Santa Clara county that had a median price of $85,000 in 1979 weighs in at $142,000 today. The median price for the same dwelling nationwide is $80,000, according to the California Association of Realtors.

Even less appealing is the Valley's traffic. The number of vehicle hours of delay—a measure of traffic congestion at selected points throughout Santa Clara County—doubled from 1980 to 1984, according to state highway officials.

Moreover, the clean image of the Valley's electronics industry has been tainted by pollution problems. For example, more than 100 leaking underground chemical tanks have been discovered in recent years. The offending firms are providing most of the money (over $100 million so far) to clean up these sites, but the stains on the industry's and the Valley's reputations are not so easily removed.

Analysts are divided on the long-term impact of the slowdown in Silicon Valley's economy. On the one hand, the export of production jobs lends credence to the notion that the Valley is becoming an R&D laboratory rather than a manufacturing center. It is a vision that troubles industrial leaders, who believe the lab works best when the plant is close at hand. "You build a ketchup factory next to a tomato patch," observes AMD's Sanders. "In the semiconductor business, the tomato patch is wafer fabrication." Intel's chairman Moore puts it bluntly: "If you move out manufacturing, R&D won't stay either."

But on the other hand, Richard Carlson, vice-president of QED Research (Palo Alto), says, "I'd be astonished if Silicon Valley did not continue to be the world leader in computer and electronics technology for the next decade." He believes that import penetration is widely overstated and that currrent conditions are the price to be paid for the overoptimism based on a fantastic 1984. The biggest problem facing the Valley, Carlson suggests, is the ability of customers to absorb the dizzying array of new products pouring out of its laboratories. Some of the technology may be outpacing the market.

The infrastructure that has supported Silicon Valley's growth in the past remains intact. For example, Stanford University, the intellectual magnet that first attracted the region's entrepreneurial scientists, is more prestigious than ever. Venture capitalists are still pouring big bucks into risky, high tech start-ups. "Deal flow is high, commercial real estate is cheap, and engineers are available," notes Bill Davidow of Mohr Davidow Ventures in Menlo Park. Dana Computer (Sunnyvale), for one, attracted $11 million in funds from 11 venture capital firms. Founded a year ago by Allen Michels, the former chairman of Convergent, Dana intends to build a "desktop supercomputer," a personal workstation that will run at the blazing speeds normally associated with Cray supercomputers. In typical Silicon Valley fashion, the company is capitalizing on advances by other Valley start-ups, most notably RISC (reduced instruction set computer) microprocessors designed by MIPS Computer Systems, a two-year-old start-up founded by Stanford professors.

Many established Valley companies, meanwhile, are maintaining their technological edge. Intel, showing resiliency in the face of a recession that has whittled revenues to 1983 levels, brought its 80386 microprocessor—one of the most advanced 32-bit microprocessors to date—into production in 1986. Five-year-old Sun Microsystems (Mountain View) has battled to the top of the market for engineering workstations, finishing fiscal 1986 with sales of $210 million, double those for '85. And Teknowledge, a Palo Alto developer of expert system software, has remained at the forefront of its field, also doubling its sales over the past year.

Moreover, the Valley is not wholly dependent on the fortunes of the semiconductor industry. Lockheed—the region's largest employer, with 25,000 workers—is building Trident II ballistic missiles, surveillance satellites, and the Hubble Space Telescope. Ford Aerospace, with 3000 employees, also builds satellites and ground stations. NASA's Ames Research Center conducts research on advanced projects like the Mach-25 aerospace plane and the X-wing helicopter/plane. In San Jose, at IBM's largest manufacturing plant in the world, 9300 workers are employed at making computer disk drives.

Profitable pharmaceutical firms such as Alza and Syntex, both of Palo Alto, are another reminder that Silicon Valley offers more than silicon. And although biotechnology pioneers Genentech (South San Francisco) and Cetus (Emeryville) lie outside the boundaries of Santa Clara County, both benefit from the high technology infrastructure that supports the Valley itself, and both contribute to its economy.

As bad as things are in the region today, the fundamental strength of that infrastructure—combined with an upturn in the national economy—could yet pull Silicon Valley out of the doldrums. Robert Arnold, chairman of the Center for Continuing Study of the California Economy, a Palo Alto economic research firm, predicts a resurgence of 25,000 new jobs in Santa Clara County by midyear, 7400 of them in high tech manufacturing. His forecast assumes that the U.S. economy will grow at an annual rate of 3%, responding favorably to the devaluation of the dollar. A cheaper dollar that can stimulate exports and raise the cost of imports, he reasons, could be more beneficial to the Valley than any single technological breakthrough. □

Some analysts fear that the export of production jobs is making the Valley more of an R&D laboratory than a manufacturing center—and that without a manufacturing base, R&D may be less effective.

Sabin Russell is a buisness writer for the San Francisco Chronicle.

For further information see **RESOURCES**, *p. 64.*

REMOTELY PILOTED VEHICLES JOIN THE SERVICE

Smart new drones are being developed for battlefield surveillance, missile guidance, and other dangerous tasks

BY PETER GWYNNE

Dismissed for several years as expensive toys of little tactical value, remotely piloted vehicles (RPVs) are finally earning a major role in military thinking, as craft that can perform a variety of functions too difficult or too hazardous for manned craft. Last year the U.S. Navy awarded AAI Corp. (Baltimore) a contract worth more than $30 million, under which it will supply three of its Israeli-built Pioneer 1 small RPV systems. Several firms are now competing for another Navy contract, this time for a midrange RPV, and for a U.S. Army contract for a general-purpose RPV. Even the Air Force—a service notoriously suspicious of aircraft that don't need human pilots—is showing interest in unmanned craft. Meanwhile, the Defense Advanced Research Projects Agency (DARPA) is carrying out research on a low-cost RPV that will stay in the air significantly longer than the several hours currently expected of drones, and is studying ways of giving RPVs the ability to alter their plans without any assistance from ground controllers. "RPVs are becoming technological marvels, embodying some of the best techniques we have in miniaturization and sensors," says James J. Croke, retired vice-president of the MITRE Corp. (Bedford, Mass.).

Two decades ago, on the limited occasions when the U.S. military used unmanned aircraft, it relied mainly on medium-size, or midi, RPVs. Today, the services show growing interest at the two extremes. Mini-RPVs, weighing under 600 pounds and derived largely from advancing model aircraft technology, have attracted the most attention. They take advantage of the increasing ability of engineers to reduce the weight and power needs of payloads. Military planners are also experimenting with maxi-RPVs, which tip the scales at between 5000 and 15,000 pounds and are designed to fly at altitudes of 50,000 to 80,000 feet for periods of days.

The assortment of shapes among RPVs is as wide as that of manned aircraft. Configurations range from the model aircraft look of the SkyEye, built by Developmental Sciences (Ontario, Cal.), to the missile appearance of the Brave series built by Boeing Military Aircraft (Wichita, Kans.); and from the flying wing form of the U.S. Army's Aquila, designed by Lockheed Missiles and Space (Austin, Tex.), to the hourglass rotary wing design of the CL-227 Sentinel of Canadair (Montreal).

The air vehicle itself represents just one component of an RPV system. Launch and landing equipment determines the nature of payloads that specific craft can carry; different RPVs can take off from airfields, hastily prepared strips, trucks, and ships, and end their missions by landing on dirt roads, dropping by parachute, or flying into nets. Just as critical to an air vehicle's mission is its ground control station, normally located in a truck and staffed by up to three operators. A typical RPV system consists of a ground control station, perhaps two portable control stations and two remote receiving stations, a single launcher and associated equipment, and anywhere from three to a dozen air vehicles.

The key to RPVs' success, however, is what rests inside the air vehicles, in the form of sensors and other electronic devices. Cameras, forward-looking infrared (FLIR) for night vision, and communications equipment for vehicle-to-ground data links can be packaged inside airframes so small that they almost inevitably evade radar detection.

Given the sophistication of such hardware and its associated software, RPVs can carry out a broad spectrum of tasks. The most fundamental is the oldest of all military missions: peering over the next hill to see what the enemy is doing and how he is doing it. But they can also carry out a passel of new missions strictly geared to modern warfare. In the reconnaissance role, they can survey battlefields for mines before attacks and assess damage after—by night as well as by day. As spotters, they can bracket targets precisely for artillery and naval guns, and guide smart missiles to military targets by illuminating the targets with lasers. Appropriately equipped RPVs can sense radiation, as well as chemical or biological contamination. They can perform a variety of communications chores, from acting as radio relay towers to jamming enemy communications and radars and eavesdropping on enemy signals intelligence. And the vehicles can take on such active tasks as dispensing flares, dropping small bombs, and acting as decoys to protect friendly aircraft.

What is common to all these tasks is that they would expose human pilots to considerable risk. The major problem in using RPVs effectively, however, is lack of sufficient precedent. "Unmanned air vehicles today are kind of where helicopters were in 1949," says industry consultant F. David Schnebly of F. David Associates (Portola Valley, Cal.). "There's lots of speculation about their military role, but very little data."

But still, the U.S. is not entirely without experience in using RPVs. The Firebee drones produced by the Teledyne Ryan Aeronautical Division (San Diego) scored impressive successes during the Vietnam War as decoys and intelligence gatherers. After Vietnam, however, the U.S. military seemed to lose interest in unmanned air vehicles, largely because the Air Force in-

SKYEYE *mini-RPV can gather electronic intelligence, carry out electronic warfare, and undertake reconnaissance missions by day and night.*

SENTINEL *CL-227 is a rotary-wing RPV designed for short- and medium-range surveillance. Its hourglass shape minimizes its radar visibility.*

BRAVE: COURTESY BOEING. SENTINEL: CANADAIR. SKYEYE: DEVELOPMENTAL SCIENCES

BRAVE *RPVs are expendable multi-mission vehicles, launched like rockets, that can carry a variety of sensing equipment or high-explosive weapons.*

sisted that they were inferior in performance to piloted craft; indeed, the only country that aggressively developed RPVs was Israel.

That Israeli investment paid off in June 1982, during the invasion of Lebanon. The relatively simple Mastiff and Scout mini-RPVs built by Mazlat (Tel Aviv) led the advance into the dangerous Bekaa Valley, undertaking key decoy work and gathering reconnaissance data on Syrian-manned, Soviet-made surface-to-air missile sites. Flying into the valley, the RPVs emitted electronic signals that mimicked radar signals from Israeli jets. When the Syrians activated their short-range radars in response to the perceived threat, the RPVs identified and passed on their locations and characteristic radar emissions, enabling Israeli smart missiles to destroy 29 SAM sites in a single hour. With the enemy air defense blinded, Israeli fighters then swept into the valley for cleanup operations, as the RPVs monitored bomb damage and the movement of Syrian forces. So significant was that action, asserts Al Ellis, director of autopilot control systems at AAI, "that no war will ever be fought without RPVs again."

At the very least, no contract will be awarded without a tip of the hat to the Israeli systems. Last year, the Pioneer 1 system marketed by AAI in partnership with Mazlat and based on the RPVs that were so successful in the Bekaa Valley, was selected as the new short-range RPV for the U.S. Navy. AAI also expects to be in a fly-off for the new Army general-purpose RPV, and plans to bid as a subcontractor in the current Navy competition for a midrange unmanned air vehicle that will also be used by the Marine Corps and the Air Force.

According to the Navy's specifications, the midrange RPV must be able to travel more than 300 nautical miles (for reconnaissance flights), acquire moderate- to high-resolution images for detecting and identifying targets, and transmit data in real time and near real time even under electronic jamming. The Navy requires that the RPV system be reprogrammable in flight. That capability will overcome objectives from some opponents of RPVs that the unmanned craft's missions are inflexible.

The most difficult requirements for the new Navy RPV will be shipboard retrieval, particularly at night in stormy seas. Lacking even the limited landing area available on an aircraft carrier, designers are exploring such methods as inflated parachutes, hooks that snag cables attached to RPVs, and flotation bag systems that will allow an RPV to parachute into the sea and await collection by a helicopter.

It is the Army, however, that has shown the most commitment to RPVs in the U.S. military. The most significant—and controversial—example of that commitment is Aquila (Latin for "eagle"), the mini-RPV built by Lockheed for reconnaissance and laser designation of targets on a future battlefield replete with nuclear radiation and chemical and biological weapons, conditions that would rule out the use of human pilots.

The 265-pound airframe is launched from a hydraulic catapult carried on a five-ton truck and assembled in the field. The heavily automated air vehicle is programmed to go to specific aerial "waypoints," loiter there for a while, and, if not otherwise instructed, move on to the next waypoint. While on station, the craft has the ability to dart back and forth in response to enemy fire—all the while lasing its target. At the end of each mission, a recovery system consisting of a giant net strung between two posts mounted like a football goal, also erected on a five-ton truck, catches the airframe. Aquila's ground control team consists of three people in another five-ton truck, protected against nuclear, chemical, and biological weapons.

As a result of Israel's experience in 1982, "no war will ever be fought without RPVs again."

In the few years after 1974, when the Army awarded the initial Aquila contract to Lockheed, the system's technology development went well, culminating in 218 flights operated by soldiers. But as the Army tightened its technical specifications, deliveries of vital subsystems were delayed, and unanticipated difficulties emerged in integrating components of the system. A major roadblock, according to Klaus D. Dannenberg, Lockheed's chief engineer for RPV programs, was integrating the controllers' work at their consoles with the actual maneuvers undertaken by the air vehicle in response to commands. Because of the nature of the secure data link, the images that operators see on their screens do not appear in real time. However, the operators react to those images as if they were happening instantaneously. As a result, their commands to the air vehicle are not always appropriate.

Lockheed solved the problem by a combination of software changes and operator training. "We arranged the software so that operators could respond more naturally," says Dannenberg. In fact, researchers are paying increasing attention to the stresses that controlling RPVs exert on ground personnel. Many react psychologically to scenes radioed back by their RPVs just as if they were piloting the vehicles in the air, says Kenneth Bosonworth, president of International Resource Development (Norwalk, Conn.). Careful training, however, can give them a more dispassionate view.

By now, most of Aquila's problems seem to have been solved. In a recent series of tests, the laser designator directed artillery fire to a target in 19 out of 20 tries (the miss resulted from a defect in the weapon rather than the RPV). If a series of operational tests now under way succeeds, the Army will make a decision to go ahead with production of the Aquila system in June, with initial deliveries planned for early 1989 and the first flights scheduled for spring 1990.

Aquila's well-publicized problems have fueled a long-running controversy over the amount of complexity that should be built into RPVs. With its multiplicity of missions—aerial reconnaissance, target location and acquisition, and laser designation—and the roughly 200,000 lines of code needed to control it, "Aquila has become an overburdened wish list," contends Howard Sterling, managing director of investment firm Rooney Pace (New York). In fact, he argues, U.S. RPV programs in general are overly complex. "The problems of loading everything onto RPVs are that costs escalate and the potential for failure soars," contends Gershon Weltman, chairman and CEO of Perceptronics (Woodland Hills, Cal.), a company working on electronic aids for RPV ground controllers. As a contrast, such critics point to the simplicity of the Israeli RPVs that scored such striking success in the Bekaa Valley.

To defenders of the Army approach, that use of RPVs was special to the situtaion. "The Israelis were using RPVs in their home town," notes industry consultant Schnebly. "They knew the local geography, and hence could use fairly unsophisticated RPVs. And their RPV operators were largely captains and majors with PhDs." Robert Rolling, former head of RPVs at Lockheed, adds that the Israeli military spent three years planing the mission in the Bekaa Valley. By contrast, he says, "we're designing for all battlefield conditions," most notably those that might arise in Europe, where protection of personnel and equipment against radiation and chemical and biological weapons is mandatory.

Controversy over how rigidly or flexibly to specify RPV systems and missions is heating up, fanned by the rapid miniaturization of electronic components: although it is now possible to package equipment for several military tasks on an air vehicle that could previously accommodate just one, programming and con-

PHOENIX *RPV, chosen by the British Army to direct artillery fire at relatively short range, can be adapted to perform electronic jamming and monitoring.*

PIONEER, *selected as the U.S. Navy's short-range RPV, is based on a simple design that proved its value in Israel's 1982 incursion into the Bekaa Valley.*

FIREBEE COURTESY TELEDYNE; PIONEER AAI; PHOENIX GEC AVIONICS

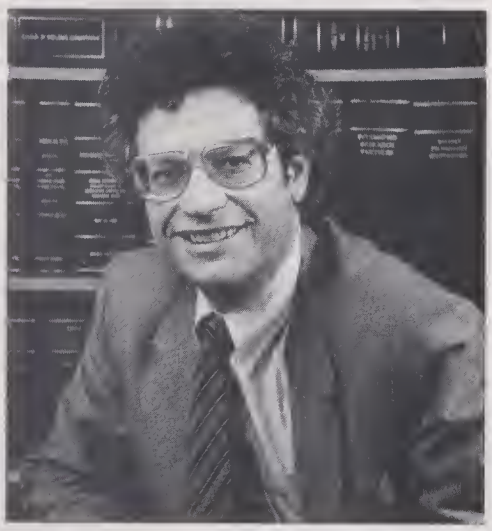
FIREBEE *drones produced excellent results in the Vietnam War as decoys and intelligence gatherers. But since then, they have been largely ignored.*

REMOTELY PILOTED VEHICLES POISED FOR TAKEOFF

Annual expenditures by the Department of Defense on remotely piloted vehicles (RPVs)—unmanned aircraft used for surveillance, signal monitoring, and other missions considered too risky for human pilots—will vary substantially over the next few years, according to the Electronic Industries Association (Washington, D.C.). Spending in fiscal 1986 was $645 million; it will jump to $837 million this year, reflecting a one-time Navy purchase of drones, but will drop to $631 million in 1988. Spending will then increase steadily to $882 million by 1995. The Army should account for half of the 1995 expenditures, followed by the Navy and the Air Force, reflecting the latter's continued suspicion of pilotless aircraft.

The actual flying vehicle accounts for a relatively small proportion of these figures. Each RPV system consists of launchers, landing equipment, and ground control stations, as well as the complex payloads, data links, and navigational systems contained within the vehicle itself. In effect, "RPVs are electronic devices, not simple fuselages," says industry consultant F. David Schnebly of F. David Associates (Portola Valley, Cal.). Electronic equipment will account for as much as 85% ($750 million) of the 1995 budget for RPVs.

The commercial market is currently focused on mini-RPVs, which weigh less than 600 pounds and fly at low altitude. That market is divided into two segments, according to Howard Sterling, managing director of Rooney Pace, a New York brokerage. At the high end are systems costing $30,000 or more that undertake complex missions involving reconnaissance, weapons targeting, intelligence gathering, and electronic jamming. Competing companies include Lockheed Missiles and Space (Austin, Tex.)—which is building an RPV for the Army—Boeing Military Aircraft (Wichita, Kans.), and Developmental Sciences (Ontario, Cal.).



"Smaller firms can best get into the RPV industry by improving the technology of motors, sensors, and vehicle retrieval."
Howard Sterling
Managing Director, Rooney Pace

"With RPVs, in contrast to most military hardware contracts, the Pentagon wants you to show that your vehicle can actually fly before it gives you an award."
Robert Nettles
VP for RPV Systems, Lockheed

At the low end, "there's a move by the Defense Department to look at cheap, lightweight, low-performance RPVs that can work with small military units," says Robert Finkelstein, president of Robot Technology (Potomac, Md.). Finkelstein also believes that simple tethered RPVs costing a few thousand dollars each might become partners to armored vehicle squadrons, reporting back on nearby views, possibly over fiber optic connections. Brandebury Aerostructures (Rockland, Md.), Perceptronics (Woodland Hills, Cal.), and H-cubed (Columbia, Md.) are exploring such low-end technology.

Foreign competition is also vigorous. Israel's Mazlat, through AAI (Baltimore, Md.), markets a short-range vehicle for the Navy. Other nations, including Canada, France, Italy, the United Kingdom, and West Germany, are also developing their own RPVs—mostly at the high end—for competition on the world market.

Whatever their nationality, RPV companies competing for U.S. contracts must now adapt to efforts by the Defense Department to reduce the lengthy procurement process. In the past, for example, the military would issue specifications for RPVs, and companies would obtain contracts to develop the technology that could match those requirements. Now, the Pentagon is insisting that companies use off-the-shelf components to produce their own, fully functional RPV systems, before they ever see a spec; what the contractor has available when bids go out may or may not match what the military wants. That procedure, says Finkelstein, tends to limit participation in the market to companies already familiar with the Pentagon's needs. Warns Schnebly: "It's not impossible to get into the business, but a company that wants to do so must be prepared to spend a lot of its own money up front to make sure its system works." □ ***—Peter Gwynne***

RAY ELLIS

trol become increasingly difficult. "You can program RPVs to react to certain situations, but a limited number of situations," explains MITRE's James Croke.

Consider, for example, the use of RPVs to transmit real-time data to ground forces. Such speed of acquisition has obvious advantages over the use of RPV-gathered photographs; enemy positions might change while the photos are being delivered. But Schnebly maintains that the engineering complexities inherent in establishing the navigation and data links necessary for real-time operation may erode overall performance. One solution is to require the RPV to transmit its video data on a slightly delayed schedule, thereby simplifying the air-to-ground link. "If you give up just a little in real time," declares Schnebly, "it can save you a lot."

A more immediate concern regards the future of manned military aircraft. Do fighter pilots face the prospect of being replaced by well-programmed payloads? Certainly planners are concluding that RPVs can play a major role in saving pilots' lives. "Instead of sending fighters in to make certain strikes," says Gen. Bernard Winters of the Air Force's Electronic Systems Division (Hanscom Field, Mass.), "I'd send in RPVs. I'm an old fighter pilot, and I'd like today's young fighter pilots also to become old fighter pilots." And Robert Finkelstein, president of the RPV consulting company Robot Technology (Potomac, Md.), says that he detects support for RPVs among current fighter pilots.

In fact, RPVs and fighters can work cooperatively, each complementing the other. Recent military campaigns have been replete with situations in which RPVs could have been profitably combined with manned aircraft, taking enough heat to reduce the threat to human pilots. The U.S. mission against Libya last year, the 1983 assault on Grenada, and the British invasion of the Falklands in 1982 all involved troops and aircraft moving into territory that was heavily protected, generally by accurate surface-to-air missiles. "In any warfare," says AAI's Ellis, "a drone is better than a man if he's going to get his head blown off."

There are also growing indications that the technology of modern military aircraft is advancing far faster than the ability of human pilots to oversee it. "We're finding more and more that the weakest link in an aircraft is the pilot," says Allen Atkins, head of DARPA's aerospace technology office. One response, exemplified by a current DARPA project, is to provide human pilots with machine help in times of excessive stress. The idea is to use the "pilot's associate"—the artificial intelligence system that interprets for the pilot much of the data vital for flying complex aircraft—to fly the plane if the pilot blacks out in high-g maneuvers.

REAGAN BRADSHAW

Lockheed's RPV vice-president Robert Nettles and chief RPV engineer Klaus Dannenberg show off Aquila.

But design teams are also working on RPV systems that would replace human pilots altogether in the most stringent aerial action, leading to scenarios in which robot planes engage each other in dogfights. DARPA already oversees action at Hollomon AFB (Oklahoma) in which RPVs, in the form of aircraft controlled entirely from the ground, take the enemy role against pilots training in F-16s. The F-16 pilots use the RPVs as movable targets—but the robots can also shoot back with gun cameras. According to DARPA's Atkins, that's just a start. "We could carry it a step further and put some AI into the system, and make the [RPV] plane a controlled escort vehicle" in real operations. Across the Atlantic, NATO's Advisory Group for Aerospace Research and Development is examining the technology and cost-effectiveness of an unmanned aircraft capable of maneuvers involving forces too high for human pilots to withstand. A ground controller would share the role of pilot with on-board artificial intelligence; the controller would make the key decisions while the computer would actually fly the plane.

That prospect isn't greeted with universal acclaim. Some segments of the Air Force, in particular, rankle at the suggestion that machines can carry out the white scarf work of human pilots. The Air Force's fiscal 1987 report to Congress checks off a series of RPV disadvantages, including inability to react to threats, susceptibility to navigational errors, and difficulty of deployment in contrast to manned aircraft. However, the anti-RPV attitude is not entirely rigid. The Electronic Industries Association (Washington, D.C.) characterizes the Air Force as ready to consider using unmanned flying vehicles to counter growing military threats to human pilots. That confirms the fiscal 1987 report's overall conclusion: "Unmanned air vehicles are needed to complement, not replace, manned systems."

Plainly, RPVs don't represent a panacea for military problems. But they do provide an extra dimension of force that, in conjunction with more traditional military technology, can increase the effectiveness of tactical operations. And RPV proponents contend they've been saying that all along. "The major impact of the Bekaa Valley exploits has been to prove that there's a niche for RPVs in the system," declares DARPA's Atkins. David Schnebly agrees. "Nobody's going to argue that unmanned systems will replace manned," he says, "but there could be a mix."

Peter Gwynne is a senior editor of HIGH TECHNOLOGY.

For further information see RESOURCES, *p. 64.*

TAKING AIM AT AIDS

As the stakes get higher, drug makers search for new weapons against the disease

BY MATTHEW HEIL AND ROBERT HEMLEY

Acquired immune deficiency syndrome (AIDS) is an impending "medical catastrophe," according to a report issued last October by the National Academy of Sciences' Institute of Medicine. Unusual for its candor and sense of urgency, the report called on the federal government to implement a $2 billion program by 1990, aimed at AIDS research, prevention, and public education. The academy noted that the sum would be a "small fraction" of the billions of dollars required for medical care if the disease remained unchecked.

NAS is primarily interested in public health, of course, and AIDS researchers—whether in government, academia, or industry—undoubtedly share its concerns. But few of the companies now enlisted in the battle against the invariably fatal disease—especially those pursuing diagnostics, vaccines, and potential therapies—are unaware of another implication of this medical priority: AIDS is becoming very big business. Consider the following statistics:

- Some 27,000 cases of AIDS have been diagnosed so far in the U.S.; 15,000 of those patients have died. The U.S. Public Health Service (PHS) predicts as many as 74,000 new cases per year by the early 1990s, and a cumulative death toll of 179,000—more than three times the number of Americans killed in Vietnam.
- An estimated 300,000 other Americans suffer from AIDS-related complex, or ARC, a loosely defined syndrome—characterized by weight loss, fever, and lymphatic disorders—that often precedes AIDS itself. And up to 3 million other apparently healthy individuals carry some form of the virus that causes AIDS, and thus may unwittingly transmit the disease.
- Whereas AIDS was once considered to be limited to homosexual males (who account for about 75% of the cases to date) and intravenous drug users, it is becoming increasingly clear that no section of society is free from risk. In fact, the PHS predicts that heterosexuals will make up about 5% of the cases by 1991, up from 2% today.
- The worldwide market for AIDS diagnostics alone is expected to climb from about $70 million today to more than $400 million by 1990, according to Fritzsche, Pambianchi & Associates, a business strategy firm in Somerville, N.J. And although a genuine cure for the disease is years away, the company predicts that the worldwide sales of an effective drug could eventually reach $1.6 billion per year—the highest revenues ever posted for any drug.

A killer called HTLV. Since AIDS was first identified in 1981, researchers have learned much about the disease and the responsible virus (called human T-cell lymphotrophic virus III, or HTLV-III). Nevertheless, there is still no way to halt or even slow its progress.

For example, HTLV-III is known to be a retrovirus; that is, it consists of a clump of the genetic material known as RNA (ribonucleic acid). When the virus invades a normal cell, it uses an enzyme called reverse transcriptase to, in effect, convert the RNA into DNA (deoxyribonucleic acid), the form of genetic material that is contained in virtually all living cells. Finally, the new DNA is integrated into that of the host cell; when the cell divides, it produces not only copies of its normal self but also new copies of the virus. Basically, then, the host cell becomes a virus factory. Unlike most other retroviruses, HTLV-III homes in on and destroys key immune-system cells called T4 lymphocytes, disabling the immune system and rendering the patient defenseless against infection. The virus also uses normally defensive cells to invade the central nervous system. And like many other viruses, HTLV-III is known to introduce defects into the host cell's DNA that cause the cell to become malignant; for example, AIDS patients are highly susceptible to Kaposi's sarcoma, a cancer of the skin and connective tissues.

Despite such extensive knowledge, the virus still defies every effort to destroy it. One reason for this frustrating state of affairs is the long time lag—up to seven years—between infection and the appearance of symptoms. Another reason is the difficulty of treating viral diseases. Since a virus takes over the host cells' reproductive processes, the cells' DNA is literally commandeered for viral replication; the virus can be killed only if every host cell is destroyed—not unlike dynamiting a house to get rid of termites.

Yet another obstacle is the variety of mechanisms all viruses use to thwart the immune system, even though it generally produces protective antibodies against the various external markings on invad-

P. F. BENTLEY; CALIFORNIA BUSINESS

Chiron CEO Edward Penhoet is steering his company into two AIDS-related markets—diagnostics and vaccines.

ing organisms. The HTLV-III is known to have at least seven such markings, and not all of them trigger an immune response, thus permitting the virus easy access to the host cells. Another viral target consists of the so-called macrophages—large cells that produce interleukin-1, an immune-system compound needed to launch a response. In fact, recent evidence suggests that HTLV-III not only disables the macrophages but also uses them as reservoirs and as transportation into the central nervous system.

Finally, an inactive and often undetectable form of HTLV-III (called a provirus) can infect a cell for years without apparent harm. Researchers are only now beginning to understand the events that trigger the provirus to assume its active form.

Although researchers hope ultimately to develop a true cure for AIDS—one that permanently and completely destroys every form of the virus—a shorter-term goal is simply to keep the organism (and the symptoms associated with it) in check, just as many forms of cancer are "controlled" rather than cured. And as with certain cancer therapies, that implies treatment at regular intervals over the life of the patient.

Improved detection. The reliable detection of AIDS has become a top priority for many companies in the highly competitive diagnostics industry; indeed, the development of the first FDA-approved diagnostic test (by Abbott Laboratories in North Chicago) was one of the speediest on record—just over a year.

One reason for the urgency, of course, is the threat to public health, primarily through infection of the blood supply. Another is the sheer size of the market for a simple and dependable diagnostic: in addition to being used by the nation's blood banks (which handle some 23 million units of blood per year), routine AIDS screening could expand to such areas as premarital testing (which would add about 5 million tests a year), hospital admissions (which totaled 38 million in 1985), and physician's office testing.

With world blood supplies at stake, sales of a reliable AIDS diagnostic test could climb to $400 million a year by 1990.

The field is now dominated by Abbott, which holds a 60% share of the market, Electro-Nucleonics (Fairfield, N.J.), and Du Pont (Wilmington, Del.). In addition, Chiron (Emeryville, Cal.), Cambridge Bioscience (Cambridge, Mass.), Centocor (Malvern, Penn.), and Genentech (South San Francisco, Cal.) have assembled AIDS-diagnostics research groups.

All of today's commercially available tests detect HTLV-III indirectly by identifying viral antibodies in the bloodstream; antibodies are immune-system proteins that are generated in response to a specific antigen (a foreign cell or organism). The test is performed by adding small samples of blood to killed HTLV-III viruses that are immobilized on plastic beads; antibodies in the blood bind to the virus, producing a detectable color change in the process. People who test positive are assumed to be infected.

These "first-generation" tests are generally compromised by several problems, however. One is a lack of specificity that

THE SEARCH FOR AN AIDS THERAPY

While researchers hold out little hope for an AIDS "cure" in the near future, several drugs seem to either fight the virus or partially relieve certain symptoms. Below, a brief look at eight of these drugs:

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Drug	Action	Manufacturer	Status and outlook
Ribavirin	Antiviral	Viratek/ICN	In clinical trials. Canada has approved for some AIDS patients.
AZT	Antiviral	Burroughs Wellcome	Toxic at higher doses. Approved for limited use in the U.S.
Foscarnet	Antiviral	Astra (Sweden)	Little data available. U.S. trials just beginning.
HPA-23	Antiviral	Rhone-Poulenc (France)	Little data available. U.S. trials still being planned.
Alpha-interferon	Antiviral	Hoffmann-La Roche, Schering-Plough	Is effective on some cancers. Now being tested on AIDS.
AL-721	Antiviral	Praxis	Works by weakening virus membrane. U.S. trials just beginning.
Interleukin-2	Immune-system stimulator	Cetus, Amgen, Biogen, Immunex, Hoffmann-La Roche, Ajinomoto (Japan)	Boosts immune-system function. Could be used with antiviral.
Isoprinosine	Immune-system stimulator; weak antiviral	Newport Pharmaceuticals	Is approved outside U.S. for other disorders. Clinical data in AIDS patients now being reviewed by FDA.

results from killing the virus: the process often changes the shape of the organism so that it binds to the wrong antibodies. Another problem is that an infected person may test negative for antibodies—the result of a three- to six-month time lag between infection and antibody generation. Yet another problem is that the tests cannot distinguish between persons who are actually infected with the virus and those who merely carry the antibody (perhaps indicating only a past exposure to, and successful defense against, the organism). As a result, some of the tests have false-positive rates of 50% and more.

For that reason, dozens of companies are now working on several approaches to the next generation of diagnostics, which are expected to begin arriving on the market later this year.

An approach being pursued by San Diego's Molecular Biosystems, for example, is to measure blood levels of adenosine deaminase—an enzyme found in white blood cells that is a reliable indicator of immune-system efficiency. The sample is used as part of a chemical reaction that is catalyzed by the enzyme; the extent of the reaction is thus an indicator of the amount of enzyme present. Since the enzyme can be depleted by other disorders, however, the test does not specifically confirm the presence of the AIDS virus—only its probable absence.

Meanwhile, Johnson & Johnson's Ortho division (New Brunswick, N.J.) has recently received approval for a test based on "crude virus extracts." In this procedure, HTLV-III is killed, broken into fragments, and immobilized on a plastic plate. When blood containing AIDS antibodies is added to the plate, the antibodies bind to the particles; the binding is detected by adding a second antibody that produces a color change when it binds to the first.

No single therapy. The search for an effective AIDS treatment, of course, is considerably more pressing than for diagnostics. However, the process will almost certainly be slower and less dramatic, largely because of the difficulty of treating viral diseases.

There are now two separate categories of anti-AIDS drugs: antivirals, which seek to destroy the virus by interfering with its reproductive cycle, and immunostimulants—agents that beef up the immune system both to combat the virus and to ward off life-threatening infection. It is possible, though, that treatment will hinge on combinations of drugs rather than on any single agent, according to Anthony Fauci, director of the National Institute of Allergy and Infectious Diseases; one or more antivirals will probably be used to fight off the virus, while immunostimulants may be called upon to restore the ability of the immune system to ward off infection. Such an approach is commonly and often successfully used in cancer therapy.

However, antivirals are often limited by their inability to cross the blood-brain barrier—a series of membranes and tissues that separate the circulatory system from the brain and spinal cord (which apparently serve as a viral reservoir). The problem arises from the different chemical natures of the two systems; drugs that are soluble in blood are usually insoluble in spinal fluid, and vice versa. Immunostimulants are compromised by the fact that they need a reasonably intact immune system to stimulate, a requirement that is usually lacking in advanced AIDS cases. Patients who can best utilize the therapy, in other words, are usually those who need it the least.

In the antiviral category, ICN/Viratek (Costa Mesa, Cal.) and Burroughs Wellcome (Research Triangle Park, N.C.) were the first to enter their products in multicenter clinical trials approved by the Food and Drug Administration—a distinction that usually (but not always) carries a clear marketing advantage. Among the companies pursuing immunostimulant research, leadership positions are occupied by Schering-Plough (Madison, N.J.) and Hoffmann-La Roche (Nutley,

N.J.), both of which produce the recently approved alpha-interferon. Meanwhile, Immunex, Cetus, and several other companies produce an immune-system stimulant called interleukin-2 (IL-2), which is also used in the experimental treatment of some forms of cancer.

The National Institutes of Health (NIH) in Bethesda, Md., has screened over 200 compounds (mostly commercial drugs) for *in vitro* activity against the AIDS virus, and last fall—considering such criteria as past use (say, as anticancer drugs), animal safety studies, and experience outside the U.S.—NIH selected five drugs for further study. It then launched a $100 million program to conduct U.S. clinical studies on the five:

- Ribavirin, an antiviral produced by ICN/Viratek. The drug is now being tested on more than 300 patients in centers across the nation, with results expected soon. Researchers suspect that the drug may help arrest ARC (the pre-AIDS condition).
- Alpha-interferon.
- Azidothymidine (AZT), an antiviral agent from Burroughs Wellcome (Research Triangle Park, N.C.). It has recently been approved for certain AIDS patients in Canada and the U.S.
- Foscarnet, an antiviral made by Astra of Sweden that appears effective against some viruses *in vitro*. The company has just begun clinical trials in the U.S.
- HPA-23, an antiviral from France's Rhone-Poulenc. The drug gained fleeting fame in 1985 in connection with the treatment of actor Rock Hudson, although there is little specific information on its activity. At this writing, clinical trials have not yet begun.

Meanwhile, other compounds being developed and tested by NIH and other agencies will almost certainly be added to the list. One example is difluorodeoxycytodine, a drug similar to AZT that was originally developed by the National Cancer Institute. NIH recently solicited bids from private companies to develop and test the drug; some 40 bids have been received so far.

Burroughs Wellcome's AZT recently received limited approval for patients with PCP (a rare form of pneumonia); recent trials suggest that the drug significantly improves the survival of this group of AIDS patients (although it carries serious side effects, including anemia and severe nausea).

Anxious to get new treatments to patients, the FDA is now taking unusual steps to hasten the approval process.

Meanwhile, Burroughs Wellcome claims to have improved AZT's ability to penetrate the blood-brain barrier by teaming with Pharmatec (Alachua, Fla.), which has developed a process for enhancing blood-brain barrier permeability 10- to 20-fold in animals. In this process, the drug is first coupled to another molecule, which renders it inert. After passing through the barrier, the two-part molecule is enzymatically converted to another form, preventing it from passing back through the barrier; reaction with a second enzyme in the cerebrospinal fluid releases the active form of the drug. By in effect boosting the activity of the drug in the brain, the Pharmatec process also reduces the required dosage.

Predictably, a number of immunostimulant producers hope to find applications for their compounds in the treatment of AIDS. Examples include IL-2, as well as Ampligen—an antiviral immunostimulant, produced by Heme Research, that appears to be active against AIDS—and Serono's thymostimulin; the latter is currently in clinical trials and is already available in Italy and West Germany.

The urgency of the situation has not been lost on the Food and Drug Administration (FDA). While the agency is unlikely to soften its demands for hard data on potential new anti-AIDS drugs, officials have taken the unprecedented step of inviting representatives of every involved drug company to Washington to clearly specify the conditions and methods of the clinical trials, thus minimizing time lost due to misunderstanding of FDA requirements.

A crystal of anti-AIDS drug AZT, which interferes with viral replication. It has been approved for limited use in the U.S.

WILL/DENI MCINTYRE

Reducing the risk. The development of an anti-AIDS vaccine is also a high-priority task at several companies, and will continue to be an important goal even after a proven treatment for the disease is found.

Vaccines prevent disease by arming the immune system against an organism before it actually infects the patient. Viral vaccines are usually produced either from viruses that have been killed or from noninfective strains of the virus; as a result, antibodies are formed in the body that will later fight off the infectious organism. "Active" vaccines provide lifelong protection with a single dose, whereas "passive" vaccines (essentially doses of antibody) must be administered at regular intervals. Because no laboratory animals are known to respond to HTLV-III exactly as humans do, and because extensive legal armor will be needed to protect companies against any liability suits, an active AIDS vaccine is at least five years away, according to MIT's David Baltimore, cochairman of

the NAS committee; protection in the near term will thus depend on passive versions.

Several companies are using viral antigens (noninfective proteins) as the basis of a vaccine. The proteins are displayed on the surface of the virus, and may themselves elicit an immune response to the intact virus without exposing the patient to infection. In this technique, which is being pursued by Chiron, Genentech, and Cambridge Bioscience, the viral proteins are chemically isolated and analyzed with commercial protein sequencers—automated devices that break the protein into its component amino acids. Knowing the amino acids and their precise sequence in the protein, researchers can then assemble synthetic versions of the protein.

The method raises at least two questions, however. First, which viral proteins will be used? The AIDS virus produces at least seven different proteins, not all of which generate antibodies. And second, will the antibodies that are formed protect against all the known strains of the virus? These questions have not yet been answered, but results of some early trials are promising. For example, researchers at the Public Health Service recently announced that one such synthetic AIDS antigen appears to generate protective antibodies in lab animals; additional animal tests are now under way at Biogen (Cambridge, Mass.) and Connaught (Swiftwater, Pa.).

That finding is significant because it clearly demonstrates that antibodies against AIDS are indeed raised—previously a matter of some doubt. Still remaining, however, is the years-long task of extending these results to humans, then overcoming the regulatory and efficacy-testing hurdles associated with any new vaccine.

Another type of vaccine could be based on a so-called anti-idiotypic antibody, or anti-id. The concept is based on the fact that protective antibodies (called the idiotype) themselves generate antibodies; because of the mirror-image relationship between antibodies and antigens, it may be possible to use these synthetic, noninfectious anti-ids—rather than the original antigens—to stimulate antibodies against the entire virus. Experimental anti-id vaccines are already being developed against a variety of diseases, including hepatitis B, encephalitis, and rabies.

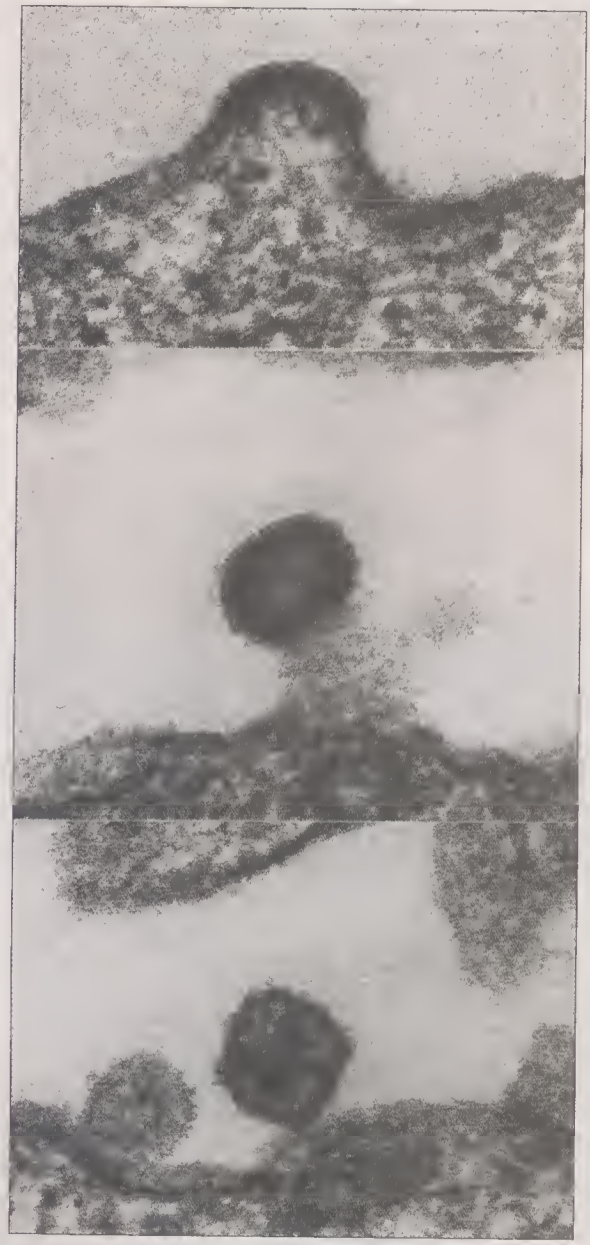
Yet another possibility is to base a vaccine on certain hormones (which carry no risk of infection), a concept being researched by several companies, including Hoffmann-La Roche, Serono, and Genentech. That approach was announced last spring by Allan Goldstein and his associates at George Washington University School of Medicine, who noted that antibodies produced against a viral hormone (called thymosin alpha-1) also react with HTLV-III; that is, the hormone apparently resembles some parts of the AIDS virus. The implication is that patients immunized with the hormone might also gain resistance to the AIDS virus, without being exposed to either the virus or its antigens.

One disadvantage of the thymic hormone method is the chance of inducing an autoimmune response to a patient's own thymic hormones, with unknown consequences. Even if the hormone itself is not used as a vaccine, however, its protein structure could be employed to learn which amino acid sequences provoke an immune response against the inactive virus.

Meanwhile, although researchers have so far been unable to isolate weakened strains of the AIDS virus for the "active" approach, an organism called HTLV-IV has recently been identified in Africa. The virus infects the immune system like HTLV-III, but does not seem to result in full-blown AIDS. Extensive tests will be needed to confirm the safety of this approach, however; such tests are now being conducted at the Harvard School of Public Health by Myron Essex, the discoverer of HTLV-IV.

A successful national defense against AIDS, of course, calls for much more than technology alone. Considering the widespread misunderstanding of the disease—which has already split apart not only families but entire communities—an extensive and innovative public-education program is also sorely needed. But beyond the necessity to address these and other problems over the long term, the most immediate requirement is for commitment by those who could ultimately provide new medical approaches to what might yet become a national epidemic. Whether or not the federal government takes up the NAS gauntlet, says MIT's Baltimore, "we must encourage greater participation of industrial researchers" in what is still a perilously inadequate battle against AIDS.

Medical technology must team up with public policy and education if a healthcare crisis is to be prevented.



Viruses reproduce by using the cell's genetic material. Top to bottom: A virus vacates a dying cell to search for a new home.

Matthew F. Heil is an immunologist at New York Medical College and a consultant for the biotechnology and healthcare industries. Robert H. Hemley is a senior analyst for Fritzsche, Pambianchi & Associates in Somerville, N.J.

For further information see **RESOURCES**, *p. 64.*

Advanced aircraft are being developed with the aid of computerized simulators that mimic aerodynamic and flight characteristics. Visual displays with 360-degree field-of-view projections create lifelike airborne situations, including tactical scenarios, weapons fire, and the effects of weather. Engineers use simulation data to improve aircraft design and performance. Hughes Aircraft Company supplies leading aircraft manufacturers with visual system components and other simulation hardware and software for flight simulators. Hughes recently installed a simulator subsystem at General Dynamics in Texas.

Direct communication between South Pole scientists and the U.S. is possible now for the first time through ATS 3, the third Applications Technology Satellite. NASA's Goddard Space Flight Center in Maryland installed a satellite antenna system at the South Pole to send and receive VHF signals from ATS 3. After over 18 years in geosynchronous orbit—well beyond the design life of seven years—the Hughes satellite is one of the last to use the low VHF frequency. Depleted of its positioning fuel, ATS 3 drifts daily into tracking ranges of ground stations at the South Pole and at the University of Miami in Florida. Communications are available for about four hours a day. The Antarctic project is a joint venture of NASA, the National Science Foundation, and private industry.

A new infrared viewer combines numerical temperature readouts and thermo-electric cooling to spot heat leaks and other energy losses more efficiently. The device is the latest model of Probeye® viewers from Hughes. As all units in the line, the Model 699 viewer sees heat the way a camera sees light and instantly converts it to a visual image. It can be used for pinpointing heating and cooling leaks and other maintenance problems in industry and commerce. A continuous digital display shows temperatures of objects in degrees Celsius or Fahrenheit. All-electric cooling eliminates the need for argon gas or liquid nitrogen, thereby cutting weight, making it easier to use, and removing restrictions by airlines and other common carriers on transporting pressurized devices.

A new infrared "eye" will help fight drug smugglers by letting U.S. Customs Service pilots see through darkness, smoke, and haze. The AN/AAQ-16 Hughes Night Vision System (HNVS), developed by Hughes, is a low-cost, computer-controlled infrared system that aids the pilot in navigation and surveillance. The AN/AAQ-16 measures minimal temperature differentials and produces a black-and-white TV-like picture for viewing on a cockpit display. The system's infrared sensor is housed in a turret mounted under the nose of the customs service's Piper Cheyenne 111A aircraft. Unlike a radar, it emits no energy and therefore cannot be detected by smugglers. The system is presently in use on both aircraft and helicopters.

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CHIP MAKERS TRY FOR FEWER DUDS

American semiconductor manufacturers are waging an all-out campaign to catch up with the Japanese in yield—the percentage of working microchips that come out of a fully processed silicon wafer. Efforts to increase automation, reduce particulate contamination, and tighten process controls are helping, but to date the Japanese chip makers are still far ahead.

Whether the semiconductor device is a complex, very-large-scale integrated (VLSI) circuit, or a commodity-type dynamic random-access memory (DRAM) chip, yield determines much of its manufacturing cost. Since a single silicon wafer may contain hundreds of individual chips that are separated after processing, the higher the yield, the lower the cost per chip.

But improving yield by even a small percentage is a difficult undertaking, because of the complexity of integrated circuit fabrication, which typically maintains tolerances measured in microns through 300–500 separate processing steps. Exacting control of parameters like processing time, temperatures, and chemical concentrations are required, and total circuit fabrication may take weeks. And circuit testing cannot take place until after processing, when the wafer is ready to be cut into individual chips for packaging.

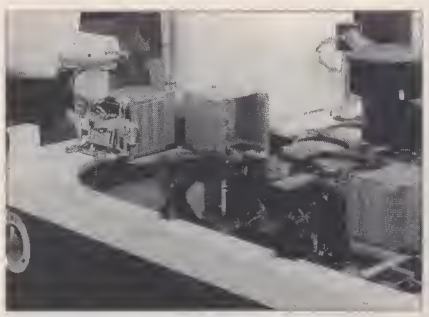
Acording to Robert England, manager of U.S. MOS operations for Texas Instruments (Dallas), reduced yield stems from "the three Ps": particulates (the tiny bits of material that contaminate the devices during processing), parametrics (losses due to process variables that are out of adjustment), and product-related failures.

Least troublesome is the last—product design errors—which account for only about 10% of yield losses. Since they occur most often when a new semiconductor device first goes into production, the solution is simply to correct the design errors so that subsequent batches will be unaffected. Losses due to particulates and parametrics, however, pose the biggest challenge. "In the latest-technology products, particulates account for about 70% of the yield loss, and parametrics about 20%," England says.

by Rick Cook

Recognizing the necessity of particulate control, National Semiconductor (Santa Clara, Cal.) recently constructed an entire new facility in Texas to make its more complex integrated circuits, even though the company's existing plants had capacity enough to meet production demands. "The old factories are just not clean enough to build the most advanced circuits," says Abbie Gregg, a semiconductor consultant based in Mesa, Ariz. "Even the small companies are spending $2–5 million to build a new room."

Recent advances in particulate control, according to Texas Instruments, are represented at its two new and identical facilities in Dallas and Miho, Japan, which primarily fabricate 256-kilobyte DRAM chips on 6-inch wafers. Rated as class-5 cleanrooms (containing no more than five 0.2-micron particles per cubic foot of air), the facilities contain class-1 fabrication areas, making them the world's cleanest, claims the company. Air is recirculated six times per minute, drawn through microscopically fine, 12-inch-thick filters before it enters the rooms through overhead vents. Air exits the rooms through thousands of small floor holes that are spaced to produce currents that divert any remaining particles from sensitive areas. Additionally, electrostatic charge neutralizers near sensitive equipment counteract the static charges on particles, which may cause them to adhere to wafers.



At TI, automated wafer handling keeps humans from contaminating chips.

"One of the biggest sources of particles in cleanrooms is the operators," says William McClean, manager of market research for Integrated Circuit Engineering (Scottsdale, Ariz.), a consulting company. "People's skin flakes off, for example, and just the residual particles exhaled by a smoker in the cleanroom can destroy a whole batch of wafers." Therefore, fabricators generally require that workers wear one-piece protective garments that envelop most of the body, and that they pass through air showers before entering the cleanrooms.

But the best way to reduce human-introduced particulates is to cut the number of operators in cleanrooms. This is the major reason for automating many manual duties, particularly materials handling.

Cleanroom automation begins with the use of "cassette-to-cassette" process equipment, says Edward Boleky, vice-president of Sierra Semiconductors (San Jose, Cal.). Rather than relying on operators who handle wafers with tweezers, these stations automatically remove wafers from the cassettes in which they're transported, load them onto wafer-holding fixtures, and feed the fixtures into the process chamber. At the conclusion of processing, the sequence is reversed, so humans touch wafers only after they're protected in the carrying cassettes.

The next major phase in cleanroom automation is to link related pieces of process equipment together within work cells. At Intel, notes vice-president of manufacturing technology Craig Barrett, this is accomplished with stationary robots and other materials-handling devices. For example, Intel has replaced human handlers with robots to move wafers between etch baths and spin dryers.

The creation of such processing cells clears the way for the ultimate tying of fabrication steps into fully automated systems. According to analyst Stephen J. Balog, assistant vice-president of Prudential-Bache Securities (New York), this step is already under way at the South Portland, Me., facility of Fairchild Camera & Instrument's Digital Products Division. In place of people, automated guided vehicles transport wafer cassettes, and an "intelligent" storage and retrieval system—supplied by the Automated Systems Division of Veeco Instruments (Melville, N.Y.)—uses bar-code scanners to keep track of the cassettes. Elements of another automated transport system, supplied by Flexible Manufacturing Systems (Los Gatos, Cal.), are being used by

AT&T and IBM in fabrication lines where the companies make chips for use in their own products, says Flexible Manufacturing vice-president Joseph Nava. Among merchant semiconductor makers, Intel (Santa Clara, Cal.), Mostek (Carrollton, Tex.), and Texas Instruments are also automating material transport, says Balog.

In addition to reducing particulate count, the replacement of workers is cited as a means of tightening parametric control. Sierra's Boleky notes that control computers are now used to store and download the various "recipes," or settings, for the cell's process equipment—a major trend in semiconductor processing, says Peggy Marie Wood, research analyst in semiconductor equipment and materials for Dataquest (San Jose, Cal.).

A useful strategy in controlling the fabrication process is to limit the flexibility of equipment; the idea is that a few dedicated sets of parameters can be more easily maintained than many variable ones, says Robert Mammano, vice-president of advanced technology at Unitrode Integrated Circuit (Merrimack, N.J.). Conventionally, variations in integrated circuits are created by changing parameters during processing to produce specific electronic characteristics in the finished chips. However, Unitrode relies on its circuit engineers to design-in product variations that can be accommodated by its standardized processes, says Mammano. For example, a particular integrated circuit application might require a transistor with double the voltage that a piece of Unitrode equipment is set up to produce. Rather than vary the equipment to produce the desired transistor, Unitrode circuit engineers may design two transistors in series, adding complexity to the circuit in order to maintain standardized processes.

Sierra's parameter-control strategy involves using equipment that's capable of tighter tolerances than called for by the design of its integrated circuits. "Instead of trying to push the equipment to its ultimate limits," says Boleky, a 1.5-micron feature on a chip may be laid down with equipment that has 1-micron capability. The finer-resolution equipment is generally more expansive and it processes more slowly, he says, but yeild increases.

Probably the most general means of controlling operating parameters—applicable across all fabrication steps—is the use of statistical process control. Ronald

Leone, vice-president of quality and productivity at Harris Semiconductor (Melbourne, Fla.), says this technique is just beginning to catch on in the U.S., although the Japanese have long relied on it. At Harris, it involves the determination of allowable upper and lower limits on such factors as furnace temperatures, alignment accuracy of photo masks, and oxide-layer thicknesses, and subsequent monitoring and sampling to determine that each variable remains within its limits. The value of this process is not only that shifts are adjusted as they occur, but also that engineers and operators are forced to find chronic problems.

Equipment monitoring at Harris is done manually. Although it could be automated, Leone says the means of data collection is secondary; more important is the use of the data to eliminate problem areas in fabrication. Similarly, workers remaining in cleanrooms at Motorola (Phoenix) are used less for manual jobs than for monitoring and troubleshooting to keep fabrication equipment operating within allowable parameters. As an incentive, the company has created a Participative Management Program, which pays bonuses that are based on yield improvement.

Motorola pays bonuses to employees who help improve yield.

Such approaches are helping American companies improve yields, although industry analysts doubt they will be able to match the Japanese any time soon. "The Japanese have been working on the problem for years," says McClean. "Thus, if you are looking at 256-kilobyte DRAM devices, the Japanese would be getting maybe 65% yield where a U.S. manufacturer would be getting 50 or 55%."

Nonetheless, "the semiconductor industry is going through a form of maturation," says Intel's Barrett. "It is moving from employing only high technology to a balance of high technology and manufacturing excellence. The folks who do a good blend of those two in the future will be the ones who are successful." □

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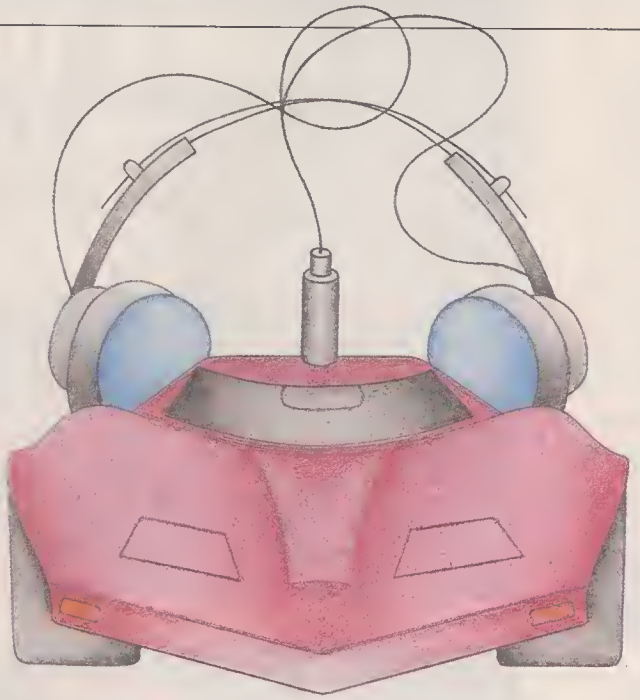
CAR AUDIO: AUTOMAKERS TUNE UP



The field of high-fidelity automobile audio has traditionally been dominated by companies whose products, whether radio/tape decks, speakers, or accessories, were installed *after* a car left the dealer's lot. Original-equipment radios were designed for those who weren't especially demanding about the quality of in-car sound. But now, automakers themselves are entering the quality-sound arena with a growing number of advanced systems that are tailored to specific car lines.

While automobile companies have been making radios for decades, they are turning to audio specialists for help in designing their top-of-the-line, customized systems. General Motors' subsidiary Delco Electronics (Kokomo, Ind.) teamed with the Framingham, Mass., speaker company Bose to produce the Delco-GM/Bose Music System, first available in 1983 and now an option on eight GM models. Ford Motor (Dearborn, Mich.) joined with JBL (Northridge, Cal.) in designing the Ford/JBL Audio System for its high-priced Lincoln Continental, Town Car, and Mark VII. Just arriving on the scene this year is the Chrysler/Infinity Sound System, customized by Infinity Systems (Chatsworth, Cal.) and soon to be available as an option in 1987 Dodge Lancer and Chrysler New Yorker and LeBaron GTS models. Also, the new Porsche 911 Turbo will soon boast the most advanced original-equipment sound system, designed by Analog and Digital Systems (ADS) of Wilmington, Mass.

In most cases, prices for these advanced audio options hover around $1000. Chrysler's will be the lowest-cost system, at around $600. The Porsche/ADS setup, priced at around $8000, will be the most expensive.

The idea of tuning an audio system for a specific car-body design originated with Bose. Already active in the aftermarket, Bose recognized in the late 1970s that a systems approach to auto sound permits engineers to design each component to work optimally with other parts of the system. "It's truly an engineer's dream," says company founder Amar G. Bose. "We know where the listeners will be sitting, and the exact acoustics of the listening environment."

Delco/Bose systems are straightforward. Single speakers are placed in the four traditional locations: one in each front door and in the two back corners above the rear seat (or rear storage area in two-seaters). The speakers themselves are housed in acoustical cabinets shaped to resonate at frequencies that enhance bass tones. GM alters the cars' interior trim designs to make room for speaker housings in acoustically correct positions, rather than squeezing them in wherever they happen to fit. Delco and Bose determine these positions through a long trial-and-error process for each car line, making acoustical measurements with the aid of an anthropomorphic dummy with electronic sound receptors for ears.

Like most car audio setups, Delco/Bose has four channels—a right-side stereo signal shared front and rear, and a left stereo signal also shared front and rear. (This is different from a home audio system, where four-channel means quadraphonic, with separate sounds for each channel.) Separate amplification on each channel allows listeners to shift the sound from front to rear, or vice versa.

But the Delco/Bose system separates itself from conventional auto sound by designed-in "equalization," whereby microprocessors divide the sound signal into individual frequency bands and boost or cut the signal in each band to compensate for natural peaks or dips created by the acoustic environment. For instance, equalization may reduce bass output from a speaker located in a large cavity near the rear window, where resonance amplifies low-register tones. Another problem is the plush upholstery in many luxury cars, which absorbs tones in the upper registers. Thus equalization is needed to boost treble to compensate for thick pile carpets and seat fabrics in, say, a Cadillac Seville or Eldorado.

Working with JBL, Ford expanded the optimized audio concept by using three speakers in each enclosure, contrasting with the single, full-range speakers used by Delco/Bose. With separate bass, midrange and tweeter (treble) speakers, the Ford system responds better to high and low frequencies in the audio spectrum, going higher in treble and lower in bass. The Ford/JBL system is also more powerful, boasting 140 watts (35 watts per channel), compared with Delco's 100 watts.

Since the Delco/Bose full-range speakers make use of neither very low bass nor high harmonics, the system's sound is more diffuse, without the extreme highs and lows that add sharp musical contrasts to the Ford/JBL approach.

Both approaches have their supporters and detractors, and both are selling well. In 1985 model cars alone, GM sold nearly 120,000 systems when they were available on only four body styles. When Ford introduced JBL systems as an option on its 1986-model Continentals, 30% of buyers—instead of the expected 15%—ordered the systems.

by Christopher Greenleaf

ILLUSTRATIONS BY DAN COLLINS

Chrysler's premium sound system, just being introduced, features six speakers. Two tweeters in the dashboard cover the high-frequency spectrum, while single speakers in the two front doors produce midrange and bass frequencies to complement the tweeters. Woofer and tweeter combinations are mounted in the two rear corners.

Sound reproduction of Chrysler/Infinity falls between the Ford and Delco systems; it gets more highs and lows than Delco/Bose, but lacks the deep bass of Ford/JBL. Chryslers' radio/tape player—supplied by Mitsubishi—is the most ambitious original-equipment offering, with features like manually operated five-band equalizer.

As one might expect in a $75,000 car like the Porsche 911 slant-nosed Turbo, the ADS audio system is the result of extensive engineering modifications. Since the 911 has a rear-mounted engine (lacking the trunk of other cars), ADS redesigned the rear of the passenger compartment, adding a hollow cabinet for mounting the speakers. Beginning in March, the West German automaker will put the system in models destined for the U.S., which is the largest auto sound market by a wide margin.

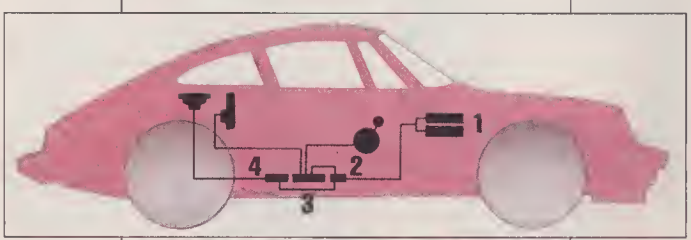
The Porsche/ADS is a six-channel system with 10 separate speakers. Four of the amplifier channels drive the four groups of tweeters and midrange speakers—a group in each door and two in the rear console. Additionally, the rear console houses two subwoofers, for the lowest basses (under 100 Hz).

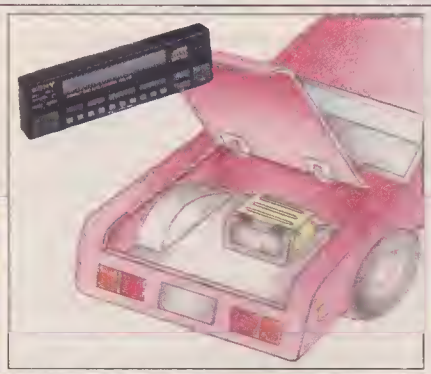
Explains ADS vice-president John Bishop, the subwoofers are isolated in the back because only the rear of the passenger compartment affords a good acoustical environment for the low-register tones to build up resonance in the small sports car. Although this configuration separates deep bass sounds from the rest of the music, the separation is not perceived by listeners because the human ear is unable to determine the direction of sounds in such a low register, he says.

Despite the advantages of original-equipment audio, true auto audiophiles generally still prefer aftermarket systems, which offer features and performance unobtainable as original equipment. For instance, the $1260 model TD 1200 II tuner/tape player from Nakamichi features a slide-out drawer for loading cassettes. As in high-quality home tape units, this loading mechanism assures precise alignment of tape and head. Also, Nakamichi was the first company to offer antitheft programming in its radios. Now being copied, the feature permits owners to electronically deactivate the radio/tape player when leaving the car. It won't play again until the correct numeric reactivation code is entered. (To prevent trial-and-error reactivation, the player shuts down after three wrong tries.) While this won't necessarily prevent first-time thefts, it teaches car-audio black marketeers to stay away from brands with this feature.

Even less expensive models, ranging in price from about $250 upward from companies such as Technics (Secaucus, N.J.), Yamaha (Buena Park, Cal.), Sony (Park Ridge, N.J.), Concord (Tarzana, Cal.), Harman-Kardon (Woodbury, N.Y.), Soundstream (Redondo Beach, Cal.), Blaupunkt (Broadview, Ill.), Philips (Hicksville, N.Y.), Kenwood (Carson, Cal.), Aiwa (Moonachie, N.J.), Denon (Fairfield, N.J.), and Pioneer (Long Beach, Cal.) also offer some features generally unavailable from original-equipment units. For instance, Blaupunkt tape players, among others, feature a bi-azimuth tape head that changes the angle at which it contacts a cassette tape when an autoreverse tape player reverses direction to play a tape's other side. At a fixed angle, a head gives good playback with the tape moving in only one direction, providing inferior sound in the other.

For Porsche's 911, ADS distributes sound signals—from either radio/tape player or compact disc player (1)—with a crossover (2) that separates bass from higher registers. A four-channel amplifier (3) powers tweeters and midrange speakers; a two-channel amplifier (4) drives subwoofers, positioned to take advantage of the inherent bass resonance produced in the space beneath the rear window.





With remote controls, audio components too large for a dashboard—such as Sony's CD player with a 10-disk magazine—can be placed in the trunk.

And even when advanced audio equipment like compact disc players are provided by the automaker—Ford offers a CD (supplied by Sony) in its Lincoln Town Car, and GM plans to introduce one later this year—they can't match the diversity of the aftermarket, which will offer as many as 30 players this year (HIGH TECHNOLOGY, Sept. 1986, p. 52). Top-line models from Sony and Alpine (Torrance, Cal.), selling for around $1000, feature 10- and 12-disk magazines that permit the listener to randomly access any selection stored on any of the preloaded CDs. Since the units are large, they're trunk-mounted with umbilical cords connecting remote controllers. The trunk mounting enhances security, and still leaves ample space in the dashboard for a tuner/tape player.

In addition to providing such advanced products, aftermarket suppliers argue that they offer the ultimate in customization, permitting users to build a car audio system around their own tastes and hearing capabilities. Matt Frankel, national sales manager of Sony's Automotive Electronics division, explains that a system designed for a listener of, say, jazz, should be configured differently from one intended primarily for classical music. Also, older listeners who may have lost some ability to pick up sounds in the higher frequencies can have systems set up to enhance these tones. "The factory system doesn't do that. It just designs the system to fit the car," says Frankel.

Components that permit aftermarket installers to fine-tune their systems include equalizers and crossovers. Graphic equalizers, which typically divide the signal frequency into as many as nine bands, allow listeners to boost or cut each band manually. And crossovers split the sound frequencies for distribution to the appropriate-sized speakers.

For aftermarket suppliers intent on protecting their $1.2 billion market—according to figures from Sony—such flexibility gives audiophiles the ability not only to tailor their systems but to expand them later, perhaps adding more powerful amplifiers or new features as they become available. Actually, many aftermarket vendors see the new wave of original-equipment systems as less a threat than a benefit. As more car buyers experience premium sound through factory systems, new audio enthusiasts could be ushered into the fold. □

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BIG SCREENS FOR SMALL COMPUTERS

The first personal computer displays consisted simply of light-emitting diodes that could make the binary output of a microprocessor visible. Now cathode-ray tubes (CRTs) that can display complex graphics and animation come standard on personal computers. But although display technology has progressed significantly during the past decade, most computer monitors remain small, low-resolution devices designed to take advantage of cheap, mass-produced TV components.

The picture is changing rapidly, however, as advanced technologies such as dedicated graphics coprocessors and very-large-scale integration (VLSI) chips equip desktop computers with screens combining text and graphics in a full 8½ × 11–inch page format. These new displays, which compare with living-room TV screens in size and offer image clarity approaching that of the printed page, are enabling micros to compete with high-end scientific and engineering workstations.

The new displays are finding their immediate applications in desktop publishing and computer-aided design (CAD). In desktop publishing, a large screen and high resolution are both indispensable for positioning text and graphics on a page. Pages laid out on a big-screen microcomputer can then be transmitted directly to a laser printer or typesetter. In CAD the large screen allows an engineer to see a schematic circuit diagram without time-consuming scrolling. But in the long run, virtually everyone is likely to demand full-page screens. Writers, for example, could view an entire page of text, and financial analysts could double or triple the number of columns and rows they could see on a spreadsheet at once.

Bigger displays demand considerably improved video circuitry, however. It is not enough simply to increase CRT size; you need more pixels to display more material. For greater clarity and detail in a big picture, you also need higher resolution. A standard Macintosh computer, for instance, displays 175,104 pixels on a 9-inch diagonal screen; but the Big Picture, a 17-inch external screen made by E-Machines for the Macintosh, displays 827,392 pixels (1024 horizontal by 808 vertical). With such high pixel counts, the CRT and associated circuitry must operate at significantly higher frequencies, presenting engineers with new design challenges. Whereas the Big Picture switches a pixel on and off once every 15 nanoseconds to refresh its 808 scan lines 60 times a second, the standard Macintosh screen switches a pixel on and off every 65 nanoseconds.

The cost of such hardware has limited large screens in the past to dedicated CAD workstations selling for $20,000 or more. Now the prospects of a large microcomputer market have brought prices down, inspiring a score of companies to develop bigger, higher-resolution screens for the IBM PC and the Macintosh. The problems posed by the two types of computer are vastly different. The Macintosh's "closed" design makes adding external video equipment difficult, but because Macintosh software is already designed for a graphics interface and Apple has established uniform development guidelines, most programs could readily take advantage of a larger display. In contrast, adding video peripherals to the IBM is easy, but the software follows no standard guidelines, particularly for graphics.

Despite its closed design, three manufacturers, following different strategies, have introduced large external monitors for the Macintosh. Programs that adhere closely to Apple's software development guidelines can now take full advantage of larger displays. Many common programs, however, do not follow the guidelines. The current versions of MacWrite, MacPaint, and Microsoft Word all have trouble with large monitors. The new displays should push software developers to follow the Apple guidelines more closely.

Radius, a company founded by members of the Macintosh design team, makes the smallest of the three available expansion monitors. The $1995 Radius FPD is a 15-inch-diagonal portrait-mode (higher than wide) display equivalent to an 8½ × 11–inch sheet. The monitor shows 864 vertical by 640 horizontal pixels with a resolution of 75 dots per inch (just slightly higher than the standard Mac's 72 dpi).

The FPD operates in concert with the existing Macintosh screen as a larger virtual display. You can move the mouse back and forth between the two screens as if they were physically connected. A main application program such as a word processor could be on the large screen while an accessory outlining program is on the standard screen. Although this design may seem odd, Radius argues that it offers the best compromise for system footprint (the FPD and Mac together take up the space of an IBM PC) and compatibility because you can switch back to the smaller Mac display at any point.

To install the display, dealers must send the Macintosh to the Radius factory for a modification that unsolders the Macintosh 68000 microprocessor and replaces it with a new socket that holds the microprocessor as well as a small logic board with additional ROM and 128 kilobytes (KB) of video RAM. The Radius ROM does not modify the Macintosh system software, so Macintosh system software developer Andy Hertzfeld has added routines that "fool" some programs into opening to the dimensions of the Radius display.

Large displays from E-Machines (left) and Micrographic Images replace the Macintosh screen altogether.

by John Markoff

In contrast to the Radius FPD, the Big Picture monitor designed at E-Machines simply displaces the Macintosh screen. Also $1995, the 17-inch Big Picture is a landscape-style (wider than high) monitor, which is best suited for computer-aided design. Its display controller mounts inside the Macintosh case, clipping on to the 68000 CPU. Rather than adding ROM to the Mac, E-Machines slightly modifies the Macintosh operating system in RAM. Although the Big Picture has many more pixels than the standard Mac screen, it can actually perform some graphics operations faster because its video RAM runs faster.

Micrographic Images' Megascreen is the largest, most expensive ($2995), and most radically designed of the three large displays for the Mac. It is a 21½-inch-diagonal display (1024 horizontal by 980 vertical pixels) and has a second mode for a standard NTSC television signal, which can be sent through a closed-circuit TV system or recorded on videotape. Micrographic Images installs two cards in the Macintosh; an interface card clips on to the 68000 central processing unit and provides a socket for an optional Motorola 68881 math coprocessor. A second card contains 128 KB of video RAM and a graphics processor that interprets the QuickDraw graphics instructions generated by the Mac.

Unlike the Mac, the IBM PC has an open architecture that makes it easy to attach video equipment. The result has been a proliferation of monitors, including large displays, and competing and incompatible graphics formats. What's worse, because there is no one standard—and because the original IBM PC and its clones were based on the slow 8/16-bit 8088 microprocessor, which was too slow for many graphics applications—IBM software developers have tended to avoid graphics altogether. Few existing programs for the IBM could take advantage of larger, clearer displays without substantial modification. Now, however, the much faster PC/AT with an 80286 processor and new desktop computers based on the even faster 80386 32-bit microprocessor should encourage graphics applications.

A major drawback to the established graphics standards for the IBM—including the Hercules Graphics Card, as well as IBM's Enhanced Graphics Adapter (EGA) and Color Graphics Adapter (CGA)—is that they have a fixed pixel count. Larger screens adopting any of these standards could display no more pixels than smaller screens, thus offering minimal improvement. Most larger displays are incompatible with existing IBM display modes and can support just a few programs. The first round of these displays worked only with specific computer aided design programs. Newer entrants can handle at least some general applications. Xerox also offers a 17½-inch monitor with 992 × 720 pixels, but it currently supports only Ventura's page layout program and a Xerox word-processing package. The biggest screen so far is the LaserView display from Sigma Designs ($1900 for 15-inch, $2400 for 19-inch); its 1664 × 200 pixels will show nearly two full pages.

Radius's large screen operates simultaneously with the Mac screen.

Several other monitors offer both an independent, higher-pixel-count mode and some compatibility with IBM standards. The $999 Wyse WY-700 supports the early IBM color graphics (not EGA) and monochrome text standards as well as its own 1280 × 800–pixel landscape mode. The Wyse display is the least expensive of the large-display options for the IBM PC, but it has the disadvantage of an interlaced display—one in which each frame is scanned in two parts, producing flicker. To combat this, Wyse uses a longer-persistence phosphor that is not ideal for many graphics applications. On the other hand, the Wyse display has a major advantage because it comes with special software driver programs that support both Microsoft's Windows and Digital Research's GEM operating environments. These environments feature a Mac-like mouse-driven interface that is independent of any specific hardware. An application program working under Windows does not need to be tailored for a particular video standard; Windows takes the program's instructions and creates the video display to suit the resolution and colors available. Unfortunately, only a few programs run under Windows.

Recently, Video-7 and Quadram introduced the first of a new generation of display controllers that could pave the way to better and bigger displays. The $599 Video-7 Vega Plus card comes bundled with Microsoft Windows and uses a set of custom VLSI graphics chips made by Chips & Technologies to support all IBM video standards plus two higher-resolution modes. It requires a flexible monitor such as NEC's Multi-Sync to take advantage of these modes. Although the Video-7 card does not support a large display, the concept behind it could be extended to design large displays for IBM PCs.

IBM video formats will continue to multiply as companies bring out new video adapters based on Intel's 82786 or Texas Instruments' 34010 graphics processors. These processors should produce yet another display standard at roughly four times the speed and pixel count of IBM's EGA. But new standards, whether set by IBM or another company, will increase the chaos in the IBM PC world. If the chaos drives more software developers to use an environment such as Windows, then users could choose video displays freely; this, however, requires nothing less than the redevelopment of MS-DOS software.

Inevitably, these changes will come. As graphics, mouse-driven interfaces, and animation become more popular, users facing vast expanses of screen will demand not only higher-resolution displays but operating systems that can support several applications at a time. Big-screen technology is likely to change the way we compute (again). □

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COMPANIES

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Hercules Computer Corp., 2515 9th Ave., Berkeley, CA 94710, (415) 540–6000
Micrographic Images, 20954 Osborne, Canoga Park, CA 91304, (818) 407–0571
NEC, 1401 Espes Ave., Elk Grove, IL 60007, (312) 228–5900
Quadram Corp., 4355 International Blvd., Norcross, GA 30093, (404) 923–6666
Radius, 1050 E. Duane St., Suite F, Sunnyvale, CA 94086, (408) 832–1010
Sigma Designs, 2023 O'Toole Ave., San Jose, CA 95131, (408) 946–3266
Ventura Software, 675 Jarvis Dr., Suite C, Morgan Hill, CA 95037, (408) 779–5000
Video-7, 550 Sycamore Dr., Milpitas, CA 95035, (408) 943–0101

AUTOMATED TELEMARKETING: RINGING IN A NEW AGE

Inexpensive computers and speech-synthesis devices are beginning to talk their way both into telemarketing applications—the selling of products or services—and into internal corporate applications that can benefit from automatic calling. Given the proper software, these systems can be more cost-effective and efficient than human callers. But public concern about being deluged by computerized sales pitches threatens to severely restrict the technology's use, and a number of state legislatures have already put certain types of automated telemarketing on permanent hold.

Today, a $10,000 system based on a personal computer can call more than 100 telephone numbers an hour, deliver synthesized voice messages in precise, well-modulated tones, recognize spoken or touch-tone keypad responses and record them, recognize and respond to telephone answering machines, and retry numbers that weren't answered the first time around. The system owner can even customize messages for different categories of recipients.

Still relatively new, PC-based calling systems have yet to be widely embraced by businesses, even where there are no legal barriers. But vendors claim the automated callers—often called auto-dialed recorded message players, or ADRMPs—could eventually become as common as spreadsheets because they can be used by virtually any type of company both for internal applications and for contacting customers.

For instance, companies could use such systems to poll their field salespeople or district managers, or to give them information on product changes. Automobile dealers could use them to notify customers that their cars are due for scheduled maintenance, to conduct follow-up calls to check on service quality, and to announce recalls. Retailers—particularly operations like Sears that combine retail stores with large catalogs—could automatically notify customers that merchandise they ordered has arrived.

Three companies offer ADRMP software that runs on IBM Personal Computers or their clones. AutoComm (Santa Monica, Cal.) sells a product called Messenger that typically costs from $5000 to $8000, depending on the configuration of the PC on which the software is bundled; the system employs a Texas Instruments speech-synthesis board. Valor Telecom (Kearny, N.J.) sells its Infotree software for $5000. Votan (Fremont, Cal.), a vendor of speech recognition equipment, offers its board-based VPC-2000, which can work over phone lines and serve in ADRMP and voice messaging applications. The VPC 2000 board fits in an IBM PC/XT chassis and costs only $1800. A fourth vendor, Invocom (Hopkinton, Mass.), plans to introduce its ACS-100 system sometime in 1987. In its first implementation, the ACS-100 will make calls across stored calling lists, but will not be configured to record responses.

PC-based systems are thrifty and efficient, but raise concerns over indiscriminate use.

These products represent a major evolution in a technology formerly dependent upon large computers and expensive software. One of the first sophisticated ADRMP systems was developed by McDonnell Douglas for use on Digital Equipment PDP-11/70 minicomputers. That product—the McDonnell Douglas Voice Information System, or MAVIS—cost several hundred thousand dollars when it was introduced in the early 1980s.

ADRMP messages and questions are typically entered via the PC keyboard and stored on a hard disk along with the list of telephone numbers to call. The message file can be built in a branching "inverted tree" structure on the more sophisticated systems, allowing them to choose among several different questions or statements depending on the yes or no responses given by the person called.

Systems can either be started and stopped manually or preset with calling times and left to operate unattended. A speech synthesis board converts the digitally stored messages into spoken messages. In another approach, some systems employ actual voices that have been digitally recorded and stored for later playback. Once their calls are completed, the computers can print out detailed reports on responses.

To record answers to questions, the latest systems digitize the incoming voice and record it on disk. AutoComm's Messenger, for instance, samples voice at 8000 bytes per second when a person responds to a question. Such high sampling rates can quickly fill a disk with recorded responses, notes David Graves, AutoComm's president. To ease this problem, the Messenger system and some others compress the recorded voices.

A new version of the Messenger, due in 1987's first quarter, will compare the voice patterns to preset ones, giving it a speaker-indepedent voice recognition capability—enough to recognize "yes," "no," and the spoken numerals zero through nine. Votan already claims such capabilities for its VPC-2000 board.

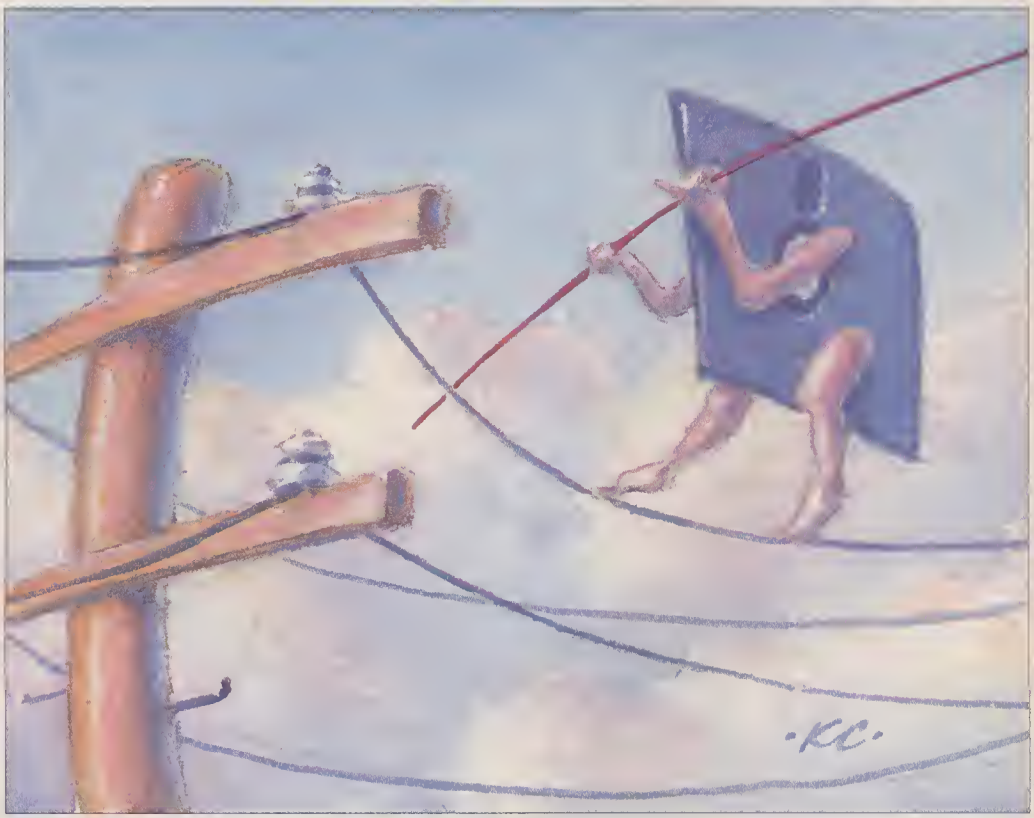
Alternatively, systems can present those called with a numbered menu of possible answers and prompt the recipients to indicate their responses by touching the appropriate buttons on their touch-tone phones. This kind of signal is easier for systems to record and process than are multitone voices. In either case, however, the system can respond interactively, choosing appropriate follow-up questions depending on the person's response.

The main operational expense of the computerized callers is creating the calling list, which is limited in size only by the capacity of the hard disk. Along with phone numbers, the list can include demographic information on each listing, customer status, and other relevant information. The systems can be programmed to call only those who fit specific criteria or to switch among different messages according to the recipient's profile.

The first application of AutoComm's

by G. Berton Latamore

Messenger system illustrates automated calling's flexibility. The Toledo school district recently bought 35 units after the Ohio state legislature passed a law requiring that parents be notified when their children are absent from school. Once the day's attendance is taken, the families of absentee students are automatically called by the computer, which is preloaded with a standard message, the phone number, the best time to call, and the language spoken in the home.



KEN CONDON

In such uses, where the caller has an established relationship with the population being called, reliance upon computerized systems is relatively easy to justify. Often, in fact, the people called are happy to receive the information, says Cecilia Pfeiffer, AutoComm's VP of sales. But the systems have an obvious downside. They can be used to arbitrarily call large numbers of people regardless of whether they wish to be called or not.

"They are giving the entire industry a bad name," says Arthur Walker, editor and publisher of *In Session* (Pleasanthill, Mo.), a newsletter that covers state legislation affecting telemarketing and related industries. In 1986, the governors of Arizona, Tennessee, and Virginia each signed laws that restrict ADRMP usage, according to Walker. The legislatures in Connecticut, Rhode Island, Georgia, Utah, and Illinois considered similar laws.

Legislators are concerned about "number dumping," in which whole telephone books are fed into the computer for indiscriminate calling, and "sequential calling," in which the computer calls every possible number in a telephone exchange. Such methods were financially impractical when telemarketing was an expensive, labor-intensive process; under such circumstances, telemarketers "prequalified" potential customers before calling them in order to get the best yield per call. But PC-based automated telemarketing systems have removed the financial incentive for extensive prequalifying efforts, raising fears of a future in which phones are constantly ringing with "junk" calls.

A related concern is the problem of automated calling systems tying up people's phone lines. Often, the systems continue their message even if a recipient hangs up, although some, including the system under development at Invocom, are programmed to hang up shortly after the recipient does. Because in many older exchanges, the person—or machine—placing the call controls the line, the recipient cannot use his or her phone until the caller relinquishes the line. "You hear horror stories about people getting calls in the middle of a medical emergency and not being able to phone for an ambulance," Walker says.

New network technology gives line control to the person receiving the call. However, thousands of the older exchanges are still operating, and replacing them all will take years.

The appropriate practices for automated calling in the public domain can only be determined by experience. But many of the vendors themselves are becoming the first line of defense against possible system abuses, which they see as a clear danger to their business. "We have established an absolute policy," says Dimitri Kastadekas, Valor Telecom's controller, "that we will not knowingly sell Infotree to any user who intends to use it for random or sequential dialing." In any case, the heaviest initial users are likely to be largely confined to the business community. □

G. Berton Latamore, based in Burlington, Vt., is editor of VideoPrint, *a newsletter on electronic publishing.*

THE VENERABLE AIRSHIP BOUNCES BACK

Some of the Navy's most advanced ships will probably never touch water. They are inflatable lighter-than-air (LTA) craft now being designed for surveillance. Motivated by a prospective Navy contract for up to 100 airships (at an estimated $65 million each), such companies as Goodyear Aerospace (Akron, Ohio), Boeing (Seattle), and Westinghouse subsidiary Airship U.S.A. (Washington, D.C.) are preparing new designs; award of the three-year contract is imminent. Although the craft are intended primarily for military service, they are also being studied for such work as engineering surveys, advertising, and materials transport.

The Navy hasn't used airships in more than two decades, but new developments in warfare could revive the concept. Accurate and relatively inexpensive air-to-sea missiles, for example, can be launched from outside a task force's usual radar coverage of 20–30 miles, making every vessel vulnerable; during the 1982 Faulkland Islands war, in fact, the British lost the HMS *Sheffield* to a single long-range Argentinian missile. The new LTAs are expected to provide vessels with an early warning system by carrying radar systems as high as two miles, thus extending coverage to 100 miles. The Navy has allotted $193 million for the design, construction, and testing of a single prototype LTA.

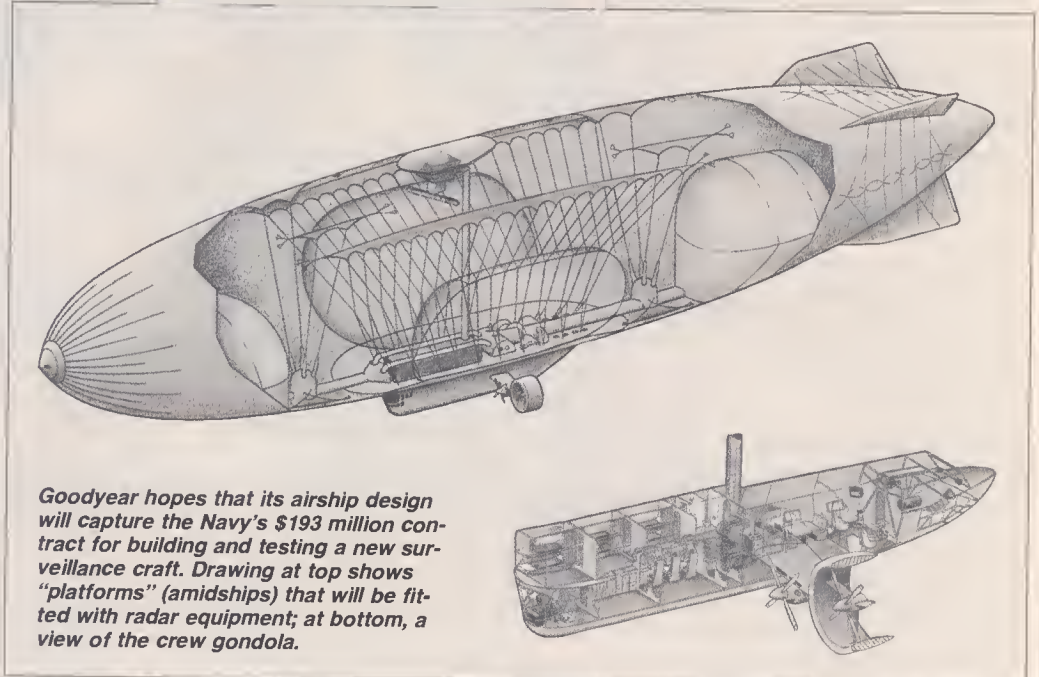
The Goodyear design includes a gondola to accommodate a crew of 12 and fly-by-wire flight control—a system that replaces conventional cables and hydraulics with weight-saving electrical circuits that are reportedly less prone to failure. The design also includes new propulsion systems that use both electric motors and gas turbine engines combined with directional vector-thrusting propellers. These systems will make the airship not only lighter but faster (cruising speed is estimated at about 80 knots, compared with 60 knots for today's airships) and more maneuverable than its predecessors.

Westinghouse is pursuing the Navy contract through Airship U.S.A., a joint venture with London's Airships Industries, which has already launched four airships used mainly for advertising. One of the craft has been remodeled for the Navy work and dubbed Skyship 600. Besides being the first airship to use a fly-by-light control system (which employs lightweight, highly reliable fiber optic technology), Skyship 600 also sports newly designed turbine engines for greater speed and maneuverability.

Meanwhile, smaller, unmanned LTAs called aerostats are in common use for a variety of jobs. For example, radar-equipped STARS (Small Tethered Aerostat Relocatable System) craft are positioned at altitudes of about 2500 feet and used by the Coast Guard and Army for air-traffic control and for monitoring ship movements; the craft was designed by TCOM (Elizabeth City, N.C.), another Westinghouse subsidiary. The U.S. Customs Service has an aerostat that hovers over the Bahamas to get better air and marine coverage of the islands in the search for narcotics traffickers, and the Air Force uses an aerostat as a "repeater": by bouncing radio signals off the craft, the range of line-of-sight communication systems is doubled.

A class of manned LTA of intermediate size, the familiar blimp, is being studied by the Canadian lumber industry as possible "sky cranes" to transport materials across impassable remote areas. Lumber's importance to Canada's economy has led to the formation of several new companies—including Aerohawk Industries, Hystar Aerospace, Aerolift of Canada, Free Enterprise Aircruiser, and Feric—that hope to employ new materials and engines.

Given their size and fragility, airships would at first appear unlikely for military applications. But their seeming vulnerability is reduced by several new techniques. Thanks to lightweight materials in the skin and frame, for example, internal pressure is only slightly higher than the outside pressure; the result is that the gas escapes very slowly if the skin is pierced, usually allowing for safe descent. In addition, to make the craft harder to detect, they will be equipped with narrow-beam radar systems. Because of their small masses of metal, the ships themselves are virtually invisible to enemy radar. □ ***—Salvatore Salamone***



Goodyear hopes that its airship design will capture the Navy's $193 million contract for building and testing a new surveillance craft. Drawing at top shows "platforms" (amidships) that will be fitted with radar equipment; at bottom, a view of the crew gondola.

SAFEGUARDING AGAINST COMPUTER MALPRACTICE

The skyrocketing cost of professional liability insurance in the wake of exceptionally high court-awarded damages for medical malpractice should give software developers food for thought. "Liability for errors in the design of computer systems is one of the most rapidly developing areas in the law," notes Jay Westermeier, a professor of computer law at Washington's American University. "The courts are increasingly receptive to the idea of computer malpractice."

For example, a suit filed last winter by Data Processing Services (DPS), an Indianapolis custom software developer, against its client L. H. Smith Oil (also of Indianapolis) backfired into a negligence claim. DPS had contracted to develop custom accounting software for Smith's IBM computers. After completion of the project, Smith refused to pay on the grounds that the software was poorly designed.

When DPS sued Smith for payment, the oil company filed a countersuit, alleging that the software was defective. In the end, the court found DPS professionally negligent and awarded damages to Smith.

Such damage awards may soon affect liability insurance rates for software developers. "These negligence awards should be of great concern to the software industry, because a negligence theory of liability gives a plaintiff the opportunity to collect a much broader range of damages (including punitive damages) than in the traditional breach of contract," says Robert Middleton, a software insurance specialist for Armfield, Harrison and Thomas (Leesburg, Va.).

Although computer malpractice may be a relatively new term, as a legal concept it is firmly based upon traditional principles of negligence law. All professionals are required by law to perform their duties and obligations with the skill and care ordinarily shown by other professionals. The key here is the term "professional." Traditionally, software developers and other computer specialists have been considered more akin to skilled tradesmen. But with the growth of professional societies, specialized degree programs, and accrediting organizations, the field of data processing has taken on an upgraded status.

Most professionals have liability exposure only for injuries done directly to their clients or to people who are the primary beneficiaries of their work. However, professionals such as architects and design engineers are subject to broader liability exposure because of the large numbers of people who use their buildings or products. This extension of liability could equally well be applied to computer professionals.

Although the implications of computer malpractice and the prospect of massive liability claims may sound ominous, there are three basic actions a software developer can take to minimize risk. Before work is undertaken, a properly drafted contract should be devised. It should carefully define the work to be performed, contain the requisite warranty disclaimers, and apportion responsibility if subcontractors are to be used. While not guaranteeing that a claim of computer malpractice will never be brought, the explicit terms of a contract will go a long way toward protecting the professional if a lawsuit were filed.

The second form of risk management is to obtain errors-and-omissions insurance. These policies provide several kinds of coverage: for claims of negligence due to a failure of the insured's own computer, for third-party claims due to a computer failure, and for any damages resulting from unauthorized access to the computer system.

The third form of risk management is simply a matter of maintaining adequate control over software development. The old saw about an ounce of prevention being worth a pound of cure is nowhere truer than in the field of data processing. □ ***—Richard Beutel***

PROTECTING OPTICAL FIBERS

Despite recent advances in fiber optic communications, some applications have been limited by the glass fibers themselves. They are susceptible to chemical attack, for example, and even ordinary moisture can permeate and expand a microscopic crack, scattering and scrambling the data being transmitted.

However, several companies have announced hermetic coatings and other treatments that not only protect the delicate fibers against chemical deterioration but also dramatically improve their mechanical strength. "Such coatings will open up applications that may not be possible today because of fiber failure or fractures that occur over long-term use," says George Sigel, director of fiber optics material research at Rutgers University (New Brunswick, N.J.).

Military applications are an important driving force behind the new coatings. The U.S. Army's prototype FOG-M (Fiber Optic Guided Missile), for example, will use an optical fiber tether for transmitting video pictures of enemy targets to ground personnel; the fibers will also be used to send commands to the on-board missile system.

One of the new coatings, called HydroShield, is a flexible titanium carbide compound developed by SpecTran (Sturbridge, Mass.). HydroShield is applied with a chemical vapor deposition process at about 4000° F (near the melting point of the glass), and is currently being evaluated by Optelecom in Gaithersburg, Md., which supplies the fiber for the FOG-M. Meanwhile, SpecTran is boosting production from prototype to commercial volumes.

Currently, SpecTran is the nation's only large-scale producer of optical fiber coatings. Hefty increases in defense expenditures could help to change that situation, however. While military uses account for only about 20% of today's fiber optics market, Charles K. Ryan, vice-president of research at Merrill Lynch (New York), predicts that this market segment will grow at an annual rate of 25% during the next few years.

JACK SPRATT

SpecTran's Ray Chaudhuri (left) and Charles Evangeline demonstrate the company's HydroShield, a high-temperature process that deposits a protective, ceramic-like film on delicate optical fibers. The coated glass fiber is taken up on spools as it emerges from the chamber.

Another process that will make optical fibers impervious to water is being developed by Corning Glass Works (Corning, N.Y.) using hermetic-coating technology acquired from Hewlett-Packard, according to James Vernon, Corning's manager of advanced fiber products. While he declines to provide details about the still-unnamed coating, he explains that it is chemically bonded to the glass at high temperatures, forming a tough layer that is measured in millionths of an inch. Corning is now furnishing experimental quantities of the coating, with commercial scale-up expected sometime this year.

The coatings don't come cheap; for example, HydroShield could add about 30% to the cost of the fiber, says SpecTran project leader Ray Chaudhuri, although prices will probably fall with increased production. Coating sales in many noncritical applications, however, will be price-limited, especially if the coating costs much more than HydroShield. "If coating a fiber doubles or triples its cost, we probably wouldn't use it," says Gary Knutsen, manager of the industrial and specialty cable group at Vector Cable (Sugar Land, Tex.), a supplier of fiber optic fibers to the oil industry. "We'd just replace the fiber if it broke." (Similarly, AT&T is opting not to coat its transatlantic optical fibers, but to inject a "greasy" sealing compound into the cable.)

Nevertheless, oil drillers are showing interest in the new coatings. The growing sophistication of test equipment has surpassed the capacity of copper cable to transmit data from exploratory wells. Whereas conventional electrical wire is limited to a few hundred kilobits per second, an optical fiber can handle 5 megabits per second. Since it must operate at underground temperatures as high as 400° F and pressures of up to 20,000 psi, however, the glass fiber must be extremely rugged.

Vector has tested several coatings, including HydroShield and the Corning product. Although specific test results are proprietary, Vector sources note that hermetically coated fiber survived intact for several months under high strain, temperature, and pressure; uncoated fibers failed in less than two days under the same conditions. The hermetically coated fibers are also impervious to glass-dissolving hydrofluoric acid, which can destroy uncoated fibers in only two minutes. □ ***—Maureen Nevin Duffy***

ten takes hours or even days; in contrast, the imagers perform the task in minutes.

PSI's Genetiscan imager consists of a microscope-mounted video camera, keyboard, computer, and two video display terminals. The stained chromosomes are displayed on one of the screens, with the images digitized so that the banding pat-

used the forerunner of the Genetiscan to assess sperm movement, a key variable in fertility studies. PSI is now working with Du Pont (which owns 20% of the company) to develop an imager to scan brain tissue and produce 3-D images of selected areas; such portraits could be helpful in designing new drugs, many of which act by at-

Another reason for PSI's lower price is Genetiscan's roots in the space program. "All the groundwork was done at JPL," says Lunney, "and as a technology transfer company, we got free access to it. The result is that we don't have as much R&D costs to recover as some of our competitors." ☐ ***—Ricki Lewis***

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Boulder, Colorado 80321-0001

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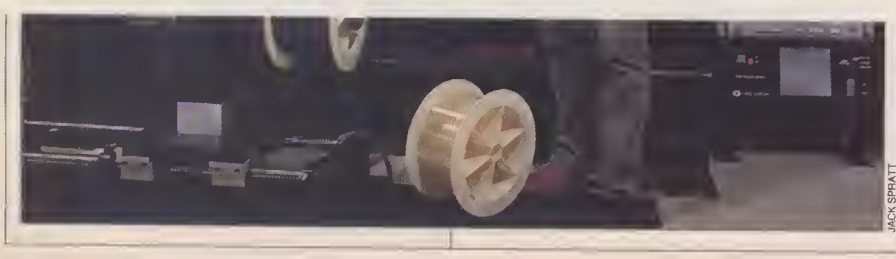
Business Reply Mail

First Class Permit No. 27, Woburn, Mass
Postage will be paid by:

HIGH TECHNOLOGY

Reader Service Department
P.O. Box 2183
Woburn, Massachusetts 01888



JACK SPRATT

for several months under high strain, temperature, and pressure; uncoated fibers failed in less than two days under the same conditions. The hermetically coated fibers are also impervious to glass-dissolving hydrofluoric acid, which can destroy uncoated fibers in only two minutes. □ ***—Maureen Nevin Duffy***

DIGITAL IMAGING AIDS CHROMOSOME ANALYSIS

A small but growing number of genetics researchers have a new tool for studying chromosomes: digital imaging systems that not only display the chromosomes but also permit the images to be sorted, enhanced, and manipulated for faster and more accurate study of genetic disorders. The imagers could also aid in prenatal diagnosis, determination of exposure to drugs and environmental toxins, and monitoring the effects of radiation.

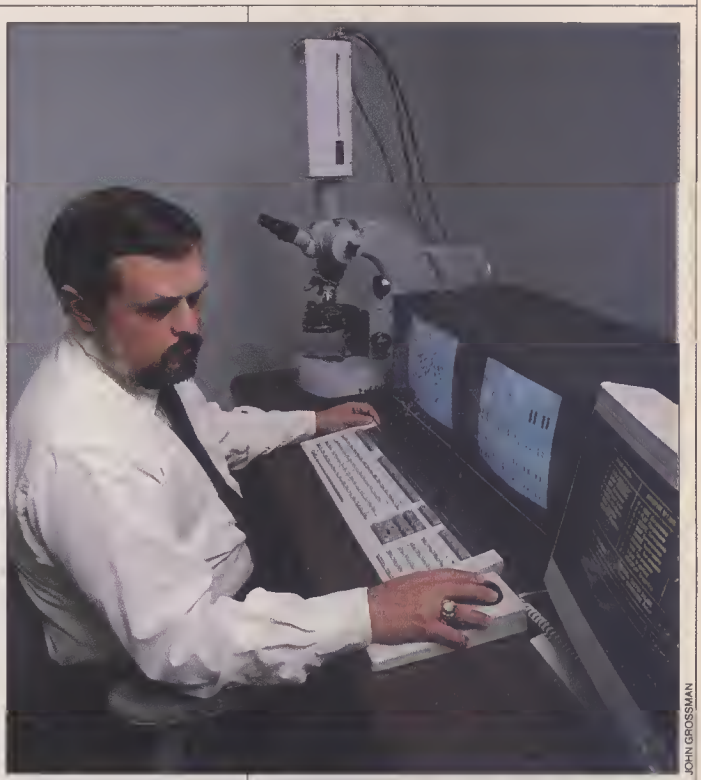
Several such imagers are now on the market, with price tags running as high as a quarter-million dollars. A relatively low-priced system, however, has recently been developed by Houston's Perceptive Systems Inc. (PSI), a company launched by "a bunch of old cowboys from the space program," according to Don Winkler, engineering VP, who formed PSI in 1984 with Kenneth Castleman, former director of biomedical image processing at Pasadena's Jet Propulsion Laboratory (JPL).

To study the 23 pairs of chromosomes contained in every human cell, researchers often prepare a karyotype—a photo in which the 46 chromosomes are paired and arranged according to size. A missing or extra chromosome—or one that is too big, too small, or rearranged—is often sufficient to confirm a diagnosis; an extra copy of the 21st-largest chromosome, for example, is a sign of Down's syndrome.

The karyotype is usually made by staining a sample of blood or other fluid with dyes that produce colored bands on the chromosomes; different DNA segments produce bands in a pattern unique to each pair. The results are photographed through a microscope and the pictures of the individual chromosomes cut out and pasted into the karyotype. Using traditional manual methods, the procedure often takes hours or even days; in contrast, the imagers perform the task in minutes.

PSI's Genetiscan imager consists of a microscope-mounted video camera, keyboard, computer, and two video display terminals. The stained chromosomes are displayed on one of the screens, with the images digitized so that the banding patterns are more clearly visible than on the original slide—an important diagnostic factor, since some genetic disorders are associated with just a single missing band.

The system features two karyotyping modes: automatic and interactive. With the first (which adds $10,000 to the $65,000 base price), the chromosomes under study are compared with others previously entered by the user, then automatically arranged into sized pairs and displayed. The problem with the automatic procedure, says one lab director now evaluating Genetiscan, is that the computer is "trained" to use the operator's personal methods, and so can perpetuate his or her errors. Many researchers, for example, mistake the fifth-largest chromosome for the sixth-largest, and the error is programmed into the computer.



JOHN GROSSMAN

PSI's Don Winkler uses the Genetiscan to create a karyotype, or chromosome chart, which is used in diagnosing genetic disorders.

The interactive mode avoids that problem by giving the user individualized control; the chromosomes are simply marked with coordinates on the first screen, and then moved one at a time to the second screen, where they are untangled, flipped, straightened, and enhanced for easier identification.

Genetiscan is one of several PSI digital imagers, and software is available for a variety of studies—counting cells and distinguishing different cell types to diagnose blood disorders, for example. While at the Johnson Space Center, Winkler used the forerunner of the Genetiscan to assess sperm movement, a key variable in fertility studies. PSI is now working with Du Pont (which owns 20% of the company) to develop an imager to scan brain tissue and produce 3-D images of selected areas; such portraits could be helpful in designing new drugs, many of which act by attaching snugly to particular bits of cell architecture.

There are now several other automatic karyotypers on the market, including models from Zeiss and from Nikon affiliate Joyce-Loebl (U.K. and Garden City, N.Y.). But Genetiscan's price tag—$95,000 or less, depending on accessories, according to PSI marketing coordinator Shawn Lunney—could give it an advantage; the other systems range as high as $250,000. One reason for the price difference, says Lunney, is that the other devices can perform functions other than karyotyping—for example, identifying cells in metaphase (a stage of division in which chromosomes are most visible), which can add $100,000 to the price.

Another reason for PSI's lower price is Genetiscan's roots in the space program. "All the groundwork was done at JPL," says Lunney, "and as a technology transfer company, we got free access to it. The result is that we don't have as much R&D costs to recover as some of our competitors." □ ***—Ricki Lewis***

RESOURCES

Information sources for topics covered in our feature articles

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Contacts

Electronic Mail Association, 1919 Pennsylvania Ave., NW, Wash., DC 20006, (202) 293–7808.

Omnicom, 501 Church St. NE, Vienna, VA 22180, (703) 281–1135. Newsletter, courses, and videotapes on electronic mail.

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Urban Land Inst., 1090 Vermont Ave., NW, Wash., DC 20005, (202) 289–8500.

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Contacts

Assn. for Unmanned Vehicle Systems, 1133 15th St., NW, Wash., DC 20005, (202) 429–9440. Serves those interested in expanded development and use of unmanned vehicle systems.

The Bristol International Conf. on RPVs, c/o Dr. R. T. Moses, Faculty of Engineering, The University, Bristol BS8 1TR, United Kingdom (0272) 303030. Unclassified international conference on RPVs held every 18 months.

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KOPIN:

Novel wafers for integrated circuits

Traditional wafers for the semiconductor industry are composed of a single material. But Kopin—from two Chinese words, *ko* (high quality) and *ping* (equitable or fair)—is developing a portfolio of technologies to combine materials such as silicon, gallium arsenide (GaAs), and gallium aluminium arsenide in a single wafer. One goal of such "wafer engineering" is to combine the best attributes of GaAs—greater speed, an ability to withstand high temperatures, and optoelectronic capability—with the low cost and ruggedness of silicon. But not all of Kopin's projects involve GaAs. For example, one technique deposits alternating layers of silicon and insulator to build three-dimensional integrated circuits. In all the techniques, the company's principals maintain, the design of the wafer material is crucial to the design of the device.

Financing: Venture capital from Eberstadt Fleming, Venrock Associates, and DSV Partners.

Management: John Fan (founder, chairman, and CEO) worked for over a decade with MIT Lincoln Laboratory's Electronic Materials Group, Paul Smith (president and COO) was VP and general manager at Harris Semiconductor's Analog Products Division, and Paul Zavracky (technical VP of operations) was principal research scientist at The Foxboro Company.

Location: 695 Myles Standish Blvd., Taunton, MA 02780, (617) 824–6696.

Founded: April 1984.

PRESENTATION TECHNOLOGIES:

Making color slides look sharp

The quality of slidemaking systems that connect to personal computers depends on the resolution of the built-in CRT. But Presentation Technologies has introduced ImageMaker—a PC-based color 35mm slide-making system that, together with ImageMate software, is a blend of phototypesetting and plotter technology with resolution limited only by the quality of film. Through menu-driven commands, a precise, electronically controlled beam of light projects text onto the film through a font cartridge, and graphics are created by the light beam directly on the film, much as a plotter controls a pen on paper. ImageMate software runs on IBM Personal Computers and compatibles, and the company is developing an Apple Macintosh driver as well.

Financing: $500,000 in seed capital from Onset Partnership, $8.8 million from investors including Kleiner Perkins Caufield & Byers, The Mayfield Fund, and New Enterprise Associates.

Management: Robert Wall (chairman and CEO) was president and CEO of MIPS Computer Systems, Allan Epstein (president and cofounder) was senior VP of corporate development at Activision, and Philip Baker (VP of product development and cofounder) was manager of product development at Polaroid.

Location: 743 N. Pastoria Ave., Sunnyvale, CA 94086, (408) 749–1959.

Founded: March 1985.

In the semiconductor industry, says Kopin's President John Fan, "two roads are merging—materials and devices."

SYBASE:

Faster database software for networking

Sybase has developed a relational database management system (DBMS) that can run on a wide range of computers. Its system consists of two components: DataServer (a relational DBMS that runs on general-purpose UNIX operating systems) and Data Workbench (a visual interface for Unix systems—soon to be released in an IBM PC version—that lets the user make queries and write reports). In combination, DataServer and Data Workbench can provide data to over 100 users in a network and can support, for example, over 35 transactions per second on a Sun-3 workstation. Sybase markets its software either alone or as a package with a general-purpose computer (such as a DEC VAX). Its chief competition comes from Britton Lee and Teradata in database machines, and from Oracle Corp. and Relational Technology in software.

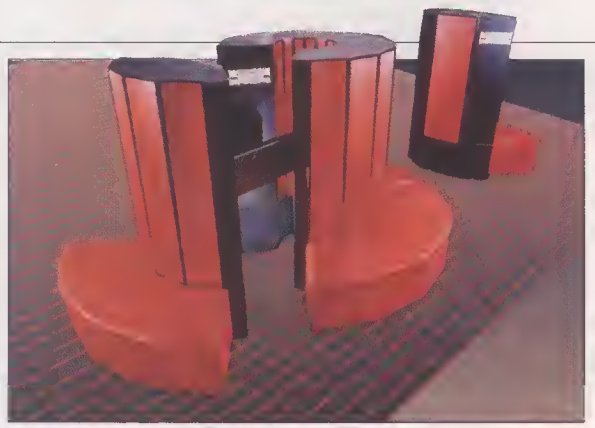
Financing: $4.75 million in venture capital from investors including Hambrecht & Quist, Kleiner Perkins Caufield & Byers, TRW, and Charles River Ventures. $2.8 million from development contracts with TRW.

Management: Founders Mark Hoffman (president) and Robert Epstein (executive VP) worked together at Britton Lee.

Location: 2910 Seventh St., Suite 110, Berkeley, CA 94710, (415) 548–4500.

Founded: November 1984.

SUPERCOMPUTERS SHOW PROMISE



Market leader Cray's X-MP supercomputer.

Supercomputers are the gazelles of the data processing world, built for speed. The fastest can crunch numbers at more than a billion calculations per second, which exceeds the combined processing power of 100,000 personal computers. But supercomputers are still a rare breed, because the world's fastest computers are also the most expensive.

With price tags traditionally ranging from $5 million to $20 million, supercomputers have been beyond the reach of most laboratories, companies, and universities. Fewer than 250 of the machines are in existence today. Until recently, access to supercomputers has been limited to a few well-funded government agencies and research laboratories that design nuclear weapons, crack top-secret codes, or analyze the weather.

It is commercial supercomputing, however, that holds the most promise for this young industry's handful of vendors. Arco and Shell are using supercomputers to search for and exploit energy reserves. Boeing relies upon supercomputers to design new airplanes. General Motors and Peugeot are testing the crashworthiness of cars under supercomputer simulation rather than against brick walls.

These applications, combined with continued government demand for the machines, could propel the annual market for supercomputers from $850 million in 1986 to $2.4 billion by 1990, according to a forecast by Piper, Jaffray & Hopwood.

Two U.S. vendors have long held a lock on the supercomputer market, but competition is heating up. Most threatening to the traditional supercomputer vendors has been the aggressive entry of three Japanese corporate giants—Fujitsu, Hitachi, and NEC—into the race. Their success in this market, however, has so far been limited.

Investors who wish to acquire stock in a U.S. supercomputer firm have just three choices: Cray Research and Control Data, both of Minneapolis, and Floating Point Systems (Beaverton, Ore.).

Cray Research (NYSE: CYR) pioneered the supercomputer industry a decade ago, and today holds more than 60% of the market. The company grew more than 65% last year in both revenues and earnings. Cray's 1986 revenues could approach $600 million from shipment of 36 new and 10 used supercomputers, and earnings per share are expected to hit $4 on a net income of $128 million. In 1987, earnings per share may reach $5 on revenues of $750 million.

To retain its preeminent position, Cray plans to spend about $75 million this year on R&D aimed at building even faster computers. The Cray-3, for example, will use gallium arsenide semiconductor technology in order to pack 16 parallel processors into a five-inch cube, yet it will be 100 times more powerful than the Cray-1.

Cray's stock, a perennial institutional favorite, has been one of the few bright spots among technology stocks recently, doubling in value since the end of 1984.

Control Data (NYSE: CDA) has lost considerable ground in recent years to its crosstown rival, but the company hopes soon to reverse that trend. In 1983, CDC created a new entrepreneurial venture, called ETA Systems, by spinning out the nearly intact Cyber 205 design team to develop a follow-on.

Now, three years and $100 million later, ETA is finally nearing its first customer delivery. The company claims its $22 million eight-processor ETA-10 will hit peak speeds of 7 billion calculations per second; less powerful versions of the system that contain fewer processors will cost as little as $2.7 million. ETA plans to install 8–12 systems next year and has received three firm orders to date.

Meanwhile, ETA's parent organization is in the midst of an extensive restructuring, including divestiture of most of its noncomputer businesses. In 1985, the company lost $568 million, or $14.56 per share, on revenues of $3.7 billion. CDC is expected to lose $51 million, or $1.25 per share, on revenues of about $3.36 billion this year. It has long been expected that CDC, in part to realize capital gains on its 89% share in ETA, would eventually allow the venture to go public. However, with the expensive development phase behind it, there is a possibility that CDC may retain its ownership of ETA.

Floating Point Systems (NYSE: FLP) reigns as the world's leading supplier of add-on scientific computers called array processors. It entered the stand-alone supercomputer arena last April with the introduction of an exotic new family called the T-Series, which links together from eight to 16,384 individual processors. Such massively parallel supercomputers may have a future, but they currently lack application software.

Since their debut, fewer than five T-Series machines have been sold. Meanwhile, FPS has experienced declining revenues and substantial losses in its mainstay business. The company is expected to earn only $850,000, or 10¢ per share, on revenues of about $100 million during 1986. Last year FPS earned $14.4 million, or $1.74 per share, on sales of $126 million; its stock has plummeted more than 70% since mid-June.

Despite FPS's shaky performance, some speculative investors may want to take a long-term flier on its depressed and out-of-favor stock, which is selling below book value. A rebound in the computer industry should put the company back on its feet. However, whether the T-series will become a viable product and contribute toward such a turnaround is anybody's guess at this point. □

by Gary P. Smaby

Gary P. Smaby is vice-president and senior technology analyst with Piper, Jaffray & Hopwood, an investment banking firm in Minneapolis.

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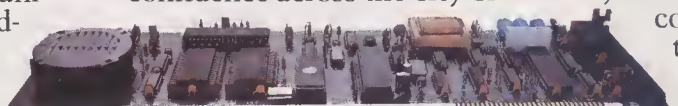

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